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PREDATION ON SURFACE AND BOTTOM RELEASED SPINY LOBSTER, *PANULIRUS MARGINATUS*, IN THE NORTHWESTERN HAWAIIAN ISLANDS

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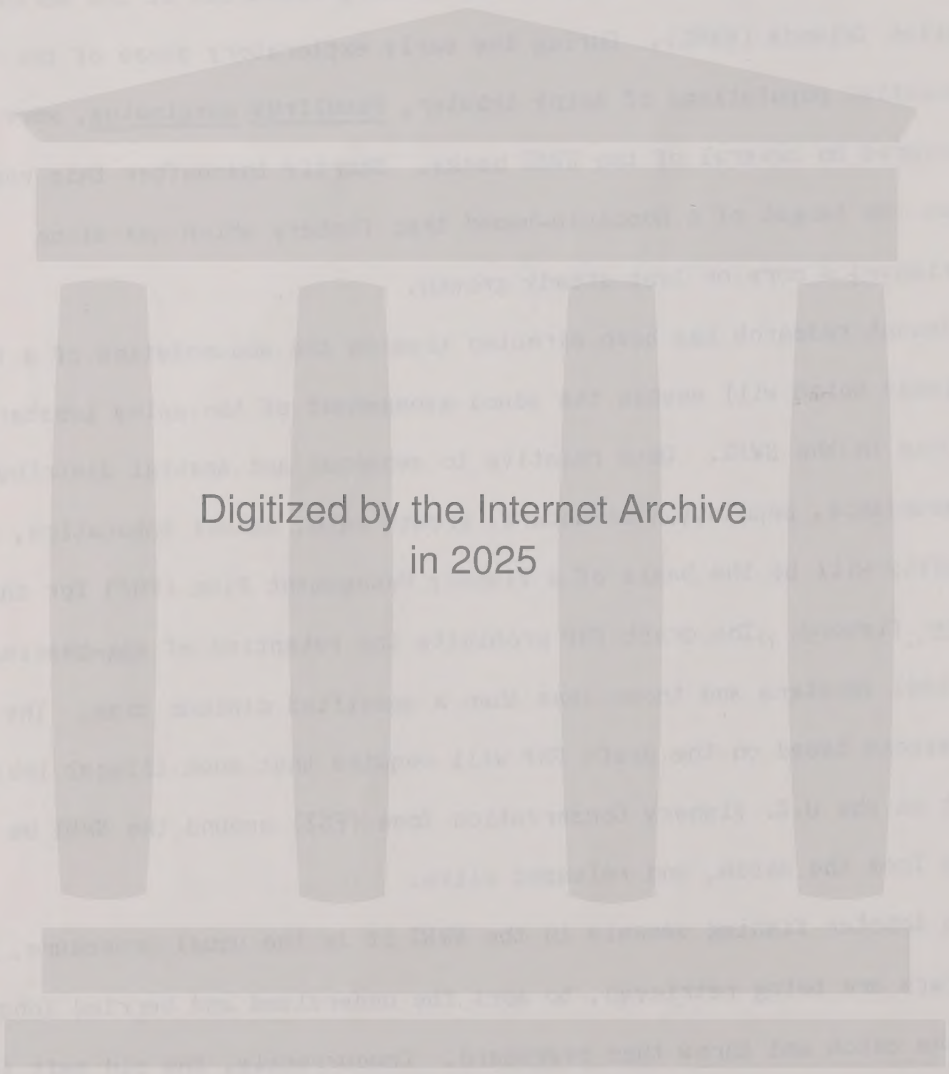

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What happens to lobsters after they have been released may be of considerable significance to the long-term productivity of the lobster fishery. Thus it is of some importance that we have an understanding of the factors which may have an effect on an animal's ability not only to survive, but also to grow and reproduce normally after it has been trapped and returned to the sea. With such an understanding it can be determined if regulations governing the way berried and undersized lobsters are treated by commercial fishermen should be included in the FMP.

Lobsters caught in traps and subsequently released are subject to factors which may cause stress, injury, or mortality. These broadly include: length of time out of the water; handling; exposure to air, sunlight, and heat; release on an unsuitable substrate; release in an area outside its home territory; general disorientation which may make the animal more vulnerable to predation; and release when lobster predators are actually around the vessel. An Australian study of fishery related mortality in undersized and berried western rock lobster, P. cygnus, shows that poor handling of lobsters prior to release causes high lobster mortality (Anonymous 1979, 1981; Rhys S. Brown, Western Australian Marine Research Laboratories, Perth, pers. commun., December 1981).

Gooding[1] reported on observations made on surface released spiny lobsters and potential predators during Townsend Cromwell cruise 79-02 near

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[1]Gooding, R. M. 1979. Observations on surface-released, sublegal spiny lobsters, and potential spiny lobster predators near Necker and Nihoa. Southwest Fish. Cent., Admin. Rep. H-79-16, 8 p. Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 96812.

Necker and Nihoa Islands in the NWHI chain. The objective of that preliminary study was to determine what fish may be potential predators on surface released lobsters. Based on a number of previously made casual observations of apparent predation on lobsters by white ulua, Caranx ignobilis, and galapagos shark, Carcharhinus galapagensis, which had been reported by fishermen and scientists on fishing vessels and on the Townsend Cromwell on earlier cruises, those two species were of particular interest to us.

On Townsend Cromwell 79-02 experiments were conducted in the presence of small schools of omilu, Caranx melampygus, two white ulua, galapagos shark, reef whitetip shark, Triaenodon obesus, and gray reef shark, Carcharhinus amblyrhynchos. There were no opportunities to run experiments in the presence of uluas either singly or in schools. With the exception of a galapagos shark, which was observed to briefly mouth a lobster in midwater before spitting it out. None of the fishes seen during that cruise showed any inclination to prey on lobsters. Parrish et al. (1980), in their trophic study of fish communities in the NWHI, found that 3.6% of the white uluas they examined had P. marginatus and 1.8% had P. penicillatus remains in their guts. Hawaii Division of Aquatic Resources (HDAR) biologists also reported lobster remains in ulua guts (Okamoto and Kawamoto 1980). While making fish surveys at Pearl and Hermes Reef they have also seen lobster antennae protruding from the mouths of white uluas, and white uluas preying on spiny lobsters which had fled from shelter when disturbed by the divers (Henry Okamoto, HDAR, Honolulu, pers. commun., December 1981).

This report describes experiments conducted during Townsend Cromwell cruise 81-04 (17 July-27 August 1981). The cruise plans called for fishing

operations throughout the length of the NWHI chain which gave us the opportunity to look for suitable experimental situations while fishing in a variety of locations. The objectives of the experiments were essentially to supplement the rather spotty data collected on previous cruises. We particularly wanted to (1) work with large schools of large white uluas to determine under what conditions they preyed on lobsters, (2) determine what other fishes are potential predators on released lobsters, (3) determine the probability of lobsters surviving predation when they are released at the surface and descend to the bottom in the presence of potential predators, particularly large white uluas, (4) determine if lobsters contained in a bag from which they can be released at the bottom are less vulnerable to predation than when they are released at the surface and allowed to descend through the water column.

Procedure

Experiments were conducted at Maro Reef, Midway Islands, and Pearl and Hermes Reef (Table 1). At Maro Reef and Pearl and Hermes Reef diving operations were conducted from the Townsend Cromwell while the ship was anchored. Procedures in general were similar to those followed during cruise 79-02.

A cage to protect the observers from sharks was suspended from the vessel's boom, either hanging in midwater or resting on the bottom. If sharks were a threat, the diver-observers stayed in the general vicinity of the cage. During this cruise shark behavior did not necessitate the use of the cage. The two or three underwater observers carried a 16-mm movie camera and a Nikonos 35-mm camera. A standby diver-observer in a Zodiac maintained position over the underwater observers. A system of hand

Table 1.—Predation observations.

Date 1981	Dive No.	Depth (ft)	Potential predators in the area	Type of lobster release
Maro Reef				
7/29	1	105	30-50 uluas, 3 galapagos sharks	Free at surface
7/29	2	105	25-40 uluas, 4-5 galapagos sharks	Midwater from bag
7/30	3	105	30-40 uluas, 5 galapagos sharks	5 ft from bottom, bag
7/31	4	100	15-20 uluas	6 ft from bottom, bag
Midway				
8/3	1	50	2 uluas	One at a time
8/4	2	55	2 uluas	Do.
8/4	3	55	2 uluas	Do.
8/5	4	50	1 uluas, 5 gray sharks	Do.
8/6	5	40	2 uluas	
Pearl and Hermes Reef				
8/8	1	60	75-100 uluas, 3-5 galapagos sharks	Free at surface
8/8	1	60	75-100 uluas, 3-5 galapagos sharks	Midwater from bag
8/8	1	60	75-100 uluas, 3-5 galapagos sharks	Bottom from bag
8/8	2	60	75-100 uluas, several galapagos sharks	Bag in midwater
8/8	2	60	75-100 uluas, several galapagos sharks	Bag on bottom
8/8	3	60	75-100 uluas, several galapagos sharks	Bag in midwater
8/8	3	60	75-100 uluas, several galapagos sharks	Bag on bottom
8/9	4	60	75-100 uluas, several galapagos sharks	Bag in midwater
8/9	4	60	75-100 uluas, several galapagos sharks	Bag on bottom
8/9	5	60	75-100 uluas, several galapagos sharks	Bag in midwater
8/9	5	60	75-100 uluas, several galapagos sharks	Bag on bottom

signals was used by the divers to communicate with the observer in the Zodiac, who monitored the underwater operation through a look-box or dive mask, and relayed messages to personnel on the vessel, e.g., when to release lobsters, lower the bag, or raise the cage. The release bag consisted of a 1.85 m x 1.85 m (6 ft x 6 ft) piece of Saran material with a grommet in the center. The line to lower the bag was tied to the grommet. In practice, the lobsters were placed on the material, and the four corners drawn up into a bag and tied together with a slipknot using the line leading from the grommet which passed inside of the bag. A 2.3-kg (5-lb) lead weight was attached to the grommet and hung outside and below the bag. When the suspending line was jerked the bag opened to release the lobsters. The combination of loosely woven Saran material, which did not trap air, and the weight permitted the bag to be lowered quickly. We had originally intended to signal the surface observer to open the bag but found that once it had been lowered from the vessel to the required position either in midwater or at the bottom, we had better control of the experiment if one of the divers jerked the line and opened the bag from a position 5-6 m (15-20 ft) above it. On some experiments to test the behavior of potential predators towards lobsters sinking through the water column, the lobsters were dropped in batches from the deck of the vessel, similar to the manner they are discarded from commercial fishing vessels. However, we found that when animals were released in this way, they usually became so widely scattered, as they descended, that it was difficult or sometimes impossible to observe and photograph subsequent events. If the bag was hung about half way to the bottom and opened by a diver, the lobsters were not as widely dispersed, thus permitting far better visual observations of predator-prey interactions, and more opportunities to take movies. Bottom

releases using the bag were not actually on the bottom because the process of jerking the line to open the bag invariably resulted in the lobsters being released about 1 m above the bottom. A bag load consisted of 10-15 lobsters. To simulate conditions on commercial vessels, which discard old trap bait concurrently as they release illegal lobsters, chum consisting of either chopped fish or whole anchovies was sometimes released from the bag along with the lobsters.

At Midway diving was conducted from a small boat. Lobsters were carried in a bag by one of the diver-observers and single animals were released in midwater while the two other divers observed. The lobsters used in all of the experiments, except a few at Midway, were trapped at either Necker, Gardner Pinnacles, or Maro Reef during the lobster surveys which concurrently were being conducted during the cruise. After removal from the traps they were put in the vessel's baitwell. We have found that lobsters maintained under these conditions and fed cut fish remain in apparent good condition for several weeks. They were removed from the tank just prior to release during an experiment. During some of the experiments at Midway lobsters were used which had been hand caught shortly before in the immediate area. We used the smallest lobsters available, however, many of the animals, especially during the work at Pearl and Hermes Reef, were considerably larger than the minimum size (carapace length (CL) of 7.7 cm) specified by the latest draft of the FMP.

Results

Maro Reef

The experiments were conducted on the western side of Maro Reef, about 5 km (3 mi) southeast of the charted anchorage ground. The area is

characterized by numerous 5–11 m pinnacles rising from depths of 30–34 m. The ship was anchored between the shallower areas in about 30 m. This area was chosen because on the evening before the first predation experiments were conducted, a 37-kg white ulua was caught by trolling in this area. It had a spiny lobster (8.6 cm CL) in its stomach. The fish was part of a school of large uluas.

Dive 1.—The cage was suspended about 6 m (20 ft) below the surface, and the diver-observers stayed at about the same depth. There were 30–50 uluas ranging from 14 to 36 kg milling about in the immediate vicinity of the divers, and three 1.2–2 m galapagos sharks were circling well outside. On this dive, as on all subsequent dives during the cruise, the uluas did not manifest any signs of fear of the divers. Frequently they would swim within a few inches of or even touch, an observer, as they passed. Such was not the case with galapagos sharks, particularly the smaller ones, which usually stayed well away from human activity.

Because, earlier in the cruise, trapping at Necker had yielded a large percentage of undersized animals, most of the lobsters released during the experiments at Maro Reef had carapace lengths of less than 7.8 cm.

Three lots of five lobsters each were released at the surface along with cut fish chum. As on experiments conducted during Cromwell cruise 79-02, the lobsters did not swim (tail flip) towards the bottom as is often characteristic of spiny lobsters, but descended limply with tail slightly curled. The uluas milled about among the sinking lobsters, and followed them to the bottom. Of the 20 lobsters released we saw only one eaten by a fish. The lobster was taken in midwater and eaten tail first. Because of the wide scatter of the falling lobsters and reduced visibility due to turbid water during the dive, we were unable to make satisfactory

observations in midwater nor were we able to see what became of the lobsters when they reached bottom.

Dive 2.--The observers went to the bottom. Water clarity had improved and because of reflection from the sandy substrate, light conditions were better than in midwater. The bag containing 15 lobsters and cut fish chum was opened 5 m (15 ft) from the bottom. About 30 large, 18-36 kg (40-80 lb), uluas surrounded the bag as it was lowered from the ship. When the bag was opened the fish were immediately in amongst the falling lobsters and chum. The fish nosed the lobsters as they were descending and ate the small pieces of fish chum. No lobsters were eaten in midwater. About 8-10 lobsters landed in a group on the sandy bottom and quickly formed a close circular phalanx with their heads and antennae facing out. The remaining lobsters landed singly and assumed a more or less upright position, tail folded beneath them and antennae extended. The bottom was coral rubble or sand and afforded no shelter in the immediate vicinity. The lobsters did not attempt to leave the area. During the 10 min of bottom time which remained for the observers, the uluas showed relatively mild interest towards the lobsters. When a fish came close, the lobsters that landed singly would rear up and extend their antennae in the typical defense posture, always keeping their tails curled tightly in a protected position. Those forming a phalanx offered what appeared to be a very effective defense with their vulnerable tails protected from attack. During the time available for observation, no lobsters were taken by the fish.

Dive 3.--The next morning when about 30-40 large uluas were around, the bag containing 15 <7.8 CL lobsters was opened about 1.5 m from the bottom in the same area. The fish were quite curious about the bag as it was lowered, and when the lobsters were released the fish were immediately in

amongst them. Several small defensive groups consisting of two to three lobsters formed, and several single animals took on the characteristic defensive posture and behavior. The fish showed a lot more interest in the lobsters than on the previous experiment. Individual lobsters and members of a group were frequently flicked around or nosed by the fish. Several times we took lobsters from the bottom and re-released them by hand about 6 m (20 ft) from the bottom. Uluas would immediately come up and follow the falling lobsters, however, no lobsters in midwater were ingested by the fish. After about 15 min and just before the observers had to ascend, two lobsters were eaten in rapid succession by two different fish. This was the first time we were able to clearly observe ingestions and the associated behavior. It became clear that the frequent nosing and flicking about of the lobsters were attempts by the fish to place the lobster in a position where it could either be (1) grabbed sideways and afterwards mouthed in a tail first position and swallowed, or (2) initially take tail first and immediately swallowed whole. After being swallowed the lobsters antennae remained protruding from the two fish's mouths for some time.

Dive 4.—The next morning with the ship anchored in the same general area, we released 15 lobsters from the bag 1.5 m from the bottom at a depth of 32 m (100 ft) where 15-20 medium sized, 14-18 kg (30-40 lb) uluas were around. No galapagos sharks were visible. The lobsters displayed the characteristic defensive behavior in groups or singly. The uluas showed considerable interest in the lobsters. The flicking and nosing action was successful in breaking up two small groups of lobsters; however, during the time we were able to remain on the bottom no lobsters were eaten or taken into a fish's mouth.

Midway Islands

All experiments were conducted from a small boat to the south of Sand Island, 1.5-2 nmi west of the channel entrance, in depths of 12-18 m (40-60 ft). The procedure simply was for one observer to hand release a single lobster at a time in the presence of the potential predators. We never had more than two uluas around during the experiments.

Dive 1.—Two 18-28 kg (40-60 lb) uluas were in the area. The two lobsters which were released had been hand caught a short time before in the same area. The first (about 8.0 cm CL) was released about 9 m (30 ft) from the bottom. It descended rapidly towards the bottom pursued by both of the fish and was caught sideways and swallowed tail first, just before it reached bottom. Shortly afterwards a second lobster (about 6.0 cm CL) was released 6 m (20 ft) from the bottom. The same fish caught it just as it reached bottom and swallowed it tail first. The ulua continued to swim around in the area with two antennae protruding from its mouth until the observers surfaced.

Dive 2.—Two 18-28 kg (40-60 lb) uluas started circling as soon as we entered the water. One observer carried two lobsters (7.5-8.0 cm CL) which had been held in the Cromwell's baitwell. The first lobster was released about 8 m (25 ft) from the bottom. It started falling limply and was eaten tail first by one of the fish. When the other lobster was removed from the bag the same ulua rapidly swam over and took the lobster from the diver's hand, and swallowed it, slightly biting his hand in the process.

Dive 3.—In the same area as the previous dive about 30 min later, the ulua that had taken the lobster from the diver's hand was still around. The antennae that had been protruding from its mouth were no longer visible. The other fish was not in sight. A lobster (about 8.5 cm CL)

that had been caught in the area a short time before, when released 8 m (25 ft) from the bottom, started a rapid tail flip descent for the bottom. The fish took the lobster tail first and ate it. The swallowing process was noticeably slower on this lobster, the third eaten within 45 min. When a fourth lobster of about the same size was released a few minutes later, the ulua, with the antennae of the lobster eaten earlier still protruding from its mouth, followed the rapidly swimming lobster to the bottom, gave it a nudge and swam away showing no more interest. Quite evidently three lobsters were all it could handle during that period.

Dive 4.—The following day in the same general area (15 m (50 ft) depth) with five gray sharks and one 18-23 kg (40-50 lb) ulua present, a slightly undersized lobster which had been held in the ship's baitwell, was released, then retrieved and re-released five times. Each time it fell to the bottom the lobster elicited very little interest from either the ulua or the sharks. The sharks left the area after a few minutes.

Dive 5.—Shortly afterwards, two uluas approximately 18 kg (40 lb) were located in 12 m (40 ft) of water several hundred yards to the west. A 7-8 cm lobster from the Cromwell's baitwell was released 6 m (20 ft) from the bottom. Both fish attacked the lobster as it descended. One fish mouthed it several times, each time getting it sideways. The other fish, on a single pass swallowed it tail first. During the following 15 min 7-8 cm CL lobsters were individually released in midwater about a dozen times. The same two uluas continued to show interest, following the lobsters to the bottom each time but no more lobsters were eaten. Afterwards a speared fish about 20 cm (8 in.) long was released. Both fish pursued it and one ate it.

Pearl and Hermes Reef

The Cromwell was anchored southwest of the small boat channel in about 19 m (60 ft) during the experiments. Conditions were excellent with calm sea and good water clarity.

Dive 1.—There were an estimated 75-100 uluas, ranging in size from about 11 to 45 kg (25 to 100 lb). The fish were very bold and curious, and started milling around the divers as soon as they entered the water. There were also several galapagos sharks in the area, but they stayed well outside the center of activity, and usually were too far away to be visible.

During the dive three experiments were run. Ten lobsters each were released (1) from the ship at the surface, (2) from the bag in midwater about 8 m (25 ft) from the bottom, and (3) from the bag close to the bottom. On these experiments and all subsequent experiments nearly all the lobsters released were larger than 7.7 cm CL, ranging up to about 9.0 cm, the largest we had used thus far. The fish voraciously attacked and ate the lobsters as soon as they were released by all three of the techniques. Of those animals that were released at the surface and in midwater, many were taken before they attained bottom. Those that reached bottom would immediately be surrounded by many fish endeavoring to take a lobster. Occasionally a fish would not be able to swallow a lobster and would spit it out, at which time many other fish would vie for it. There was often a very audible crunch when an animal was taken sideways. The uluas followed the bag down to the bottom, and many fish were immediately in amongst the lobsters as they were released. Most of the lobsters were taken before they could group into a defensive circle. Those animals that did survive the initial attack, immediately had a gang of fish surrounding them and

within a few seconds were eaten. None of the 30 lobsters survived for more than a few minutes after release.

Dive 2 and 3.—Four releases of ten lobsters each, two in midwater and two near the bottom were made during two dives in the following 1.5 h. The feeding capacity of the school was undiminished throughout the experiments and none of the released lobsters survived.

Dive 4.—The experiments were conducted in approximately the same area as on the previous day and probably with the same school of 75-100 uluas. There were also several galapagos sharks and gray sharks in the outlying area.

On the first experiment, when ten 8-9 cm CL lobsters were released from the bag in midwater about 10 m (30 ft) from the bottom, dozens of fish were around the bag as it opened. The lobsters were eaten so fast that it was difficult to see or film the action. All the lobsters were gone within about 10 sec and none reached the bottom. Shortly afterwards another batch was released at the bottom. Again dozens of fish crowded around, and all 10 lobsters were gone within seconds of release. For the first time we saw a large ulua take a lobster head first into its mouth. This fish swam around for several minutes with the tail protruding from its mouth, apparently unable to swallow it. When we returned about an hour later on dive No. 5, no protruding tail was observed.

Dive 5.—This was a repeat of the previous experiments. Ten each lobsters were released in midwater 6 m (20 ft) from the bottom, and on the bottom. Most of those released in midwater were eaten before reaching bottom, but the four animals that did get there assumed a defensive posture and lasted a little longer than on previous experiments with this school of fish. Although many fish continuously circled each lobster, the last one

was not taken until several minutes later. On the following experiment the last individual of the batch of 10 released on the bottom managed to survive for about 5 min, and our impression was that the rate of serious attempts by the ulua to capture lobster had definitely decreased to a noticeable degree.

On those two experiments where slower action prevailed, it became more evident that in this school only the larger fish were eating or even mouthing lobsters of the size we were releasing. It was, however, difficult to estimate the size of the smallest fish which was able to ingest lobster of the size we were releasing. Our rough guess was about 16 kg (35 lb).

Figures 1-4 show uluas preying on lobsters at Pearl and Hermes Reef. Also during the experiments about 1,000 ft of 16-mm movies were taken at normal speed and in slow motion (48 and 64 frames/sec).

Experiments With Galapagos Sharks

During the experiments at Maro Reef and Pearl and Hermes Reef there usually were relatively small galapagos sharks (<2 m) in the vicinity. They always stayed well outside the center of activities and never approached a lobster or showed any inclination to do so.

While anchored off Necker Island one afternoon we chummed with cut fish, and soon had several galapagos sharks ranging up to 2 m in length around the vessel. While chumming with fish, live lobsters tied to a light line were hung in the water amongst the chum. Sharks on numerous occasions came up to the lobsters with open mouth and turned just before reaching the lobster, or sometimes nosed it. The same thing was tried with lobster tails and heads, with the same results. However, when the exoskeleton was removed from a tail and only the muscle was hanging in the water a shark

took it immediately and swallowed it. The experiments with a live lobster and complete tail were repeated while pouring fish blood into the water. The sharks went into a frenzy of feeding excitement, continuously nudging the lobster without taking them, except once, when the exoskeleton of a tail, from which the muscle had been removed, was taken into a shark's mouth for a moment and spat out. When fish (Bodianus sp.) were hung on a line the shark bit them off and ate them without hesitation.

Tiger shark, Galeocerdo cuvieri, are known lobster predators. Parrish et al. (1980) found that 15% of the tiger shark guts they examined contained remains of P. marginatus, however, no tiger sharks were present during our observations.

DISCUSSION AND CONCLUSIONS

In any study wherein the natural environment is modified because of the presence of man, the question as to how experimental results are affected must be addressed. We do not think that the presence of divers, even in the immediate vicinity, had a significant effect on the feeding behavior of uluas relative to spiny lobsters. This was not so with galapagos sharks. Usually galapagos sharks will swim very close to a ship, and show no hesitancy to approach any potential foodlike items that are tossed or hung in the water. However, during the diving experiments on this cruise the galapagos sharks stayed well away, even when there presumably was some degree of olfactory stimulation produced by the fish-chum which was released with the lobsters during some of the experiments. It seems likely that the behavior of the relatively small sharks we saw during the experiments was influenced by diver activity, and had no divers been around, the sharks would have come in closer to the release bag and the

area in which lobsters were released. However, although the experiments with diver-observers described herein may not have provided reliable data on whether galapagos sharks are predators on released lobsters, other evidence indicates that this species does not prey on spiny lobsters. Parrish et al. (1980) did not find any lobster remains in the gut contents of 42 galapagos sharks they examined, and during Townsend Cromwell cruises 79-02 and 81-04, attempts to induce large surface swimming galapagos sharks to ingest live lobsters or parts of lobsters, except tail muscle, were unsuccessful.

During this cruise we were able to work with large schools of large white uluas at Maro Reef and at Pearl and Hermes Reef, and with pairs and individuals at Midway. The fish at Pearl and Hermes ranging from 14 to 45 kg were very voracious predators on lobsters which were for the most part considerably larger than animals which would be discarded by commercial fishing vessels under the legal minimum prescribed in the draft FMP. Large schools of uluas which were, on the average, somewhat smaller (14-38 kg) at Maro Reef displayed far less interest in smaller lobsters that should presumably be more easily ingestible. At Midway pairs of fish and single fish in the 25 kg range fed avidly on lobsters of up to about 8.5 cm CL.

Our data are insufficient to permit any analysis of the variability of the feeding behavior of uluas on lobsters which was observed during the experiments. State of satiation must always be a factor, and the potential number of lobsters which can be consumed by a school must be related to fish size and to lobster size as well as size of school. Other factors might include: feeding frenzy of the fish and behavior of the lobsters.

Prior to this study we had hypothesized that the type of substrate over which lobsters were released could significantly affect predator success,

as it would affect the ability of the lobster to protect itself and find shelter when it reached the bottom. The latter would be dependent on aspects of its physical condition such as walking leg and antennae condition, and ability to orient rapidly to the new environment. Our observations were mostly made over substrates which afforded little shelter in the immediate vicinity and with lobsters, excepting a few at Midway, that had been held in captivity for periods up to 2 weeks. The markedly different behavior of recently caught lobsters which tail flip to the bottom when released in midwater, as opposed to the behavior of animals held in captivity for some time which fall limply to the bottom, may indicate that lobsters which have experienced prolonged captivity are handicapped in their ability to adjust to a sudden reintroduction into their natural environment. Thus our experiments may have been conducted under conditions which placed the lobster in a less advantageous situation than if a commercial vessel held its undersized and berried animals for only a short time before releasing them. Despite the above-mentioned limitations of our experimental conditions, based on our observations of the ability of large uluas to effectively prey on lobsters, we do not think that lobsters released in the presence of ulua schools, even on a substrate which affords good shelter, can be effectively protected with a bottom release system or any other practical system. Probably the only practical way to safeguard lobsters is to release them from a bag at the bottom when there is reasonable assurance that the substrate offers shelter, and that uluas are not around the vessel. As water depths on the NWHI grounds are too great to make visual checks of the bottom type the release would best be made on known fishing grounds. Ulua schools are not so plentiful on the NWHI banks that, if a vessel has the capacity to hold all or part of the

day's catch of illegals in a circulating water tank and the fishermen are willing to handle the lobsters with reasonable care and wait for a suitable time and place before releasing them, this should not be quite practical. Such a procedure will not protect every lobster from predation, but if it is followed we do not think that predation from uluas will be seriously detrimental to the lobster population in the NWHI fishery.

These observations have conclusively verified what had previously been suspected. White ulua do prey on lobsters which have been released at the surface from commercial fishing vessels in the NWHI, and a large school of hungry fish may have the ability to consume several hundred lobsters.

All available information indicates that galapagos sharks are not a significant threat to released lobsters.

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Figure 1.--A rare instance of an ulua attempting to swallow a lobster head first.

Figure 2.--An ulua swallowing a lobster tail first.

Figure 3.--Fish milling around lobsters on the bottom looking for an opportunity to attack.

Figure 4.--Uluas attacking a lobster which has just landed on the bottom and has not been able to assume a defense posture.

PRELIMINARY DESCRIPTION OF THE WESTERN PACIFIC FISHERY INFORMATION NETWORK

BY
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INTRODUCTION

Since the passage of Magnuson Fishery Conservation and Management Act in 1976 there has been a dramatic increase in the need for timely reporting of accurate data on fisheries resources to make management decisions and prepare Fishery Management Plans. As development and management of fisheries resources have evolved, there have been increased data needs by the National Marine Fisheries Service (NMFS), the Regional Fishery Management Councils, and by state and territorial fisheries agencies. Various user and management groups have encountered the following data related problems: lack of a historical fisheries data base, unavailability of existing data for analysis, legal constraints for data exchange, lack of data standardization, and inadequacy of data collection procedures. To help resolve these problems in the Pacific area and provide a central source of region-wide fishery data, the Southwest Fisheries Center (SWFC), NMFS, developed the concept of the Fishery Information Network (FIN).

The FIN is divided into three entities: the California FIN (CALFIN) involving NMFS and California Fish and Game; the Pacific coast FIN (PACFIN) composed of NMFS and the fisheries offices in all the western U.S. coastal states plus Idaho; and the Western Pacific FIN (WPACFIN) comprised of NMFS and fisheries agencies from American Samoa, the Northern Mariana Islands (NMI), Guam, and Hawaii.

The overall purpose of FIN is to provide ready access to quality fisheries data needed for management purposes. To achieve this goal, several broad activities have been identified:

1. Enhancement and modernization of existing fisheries information management and data collection systems.

2. Development and implementation of new information management and data collection systems.

3. Establishment of both central and distributed, computerized data bases containing pertinent fisheries data needed for management purposes.

4. Establishment of a communication network between state, territorial, and NMFS data collecting and processing groups thereby providing a mechanism for the access and exchange of the computerized fisheries data bases.

The FIN has been designed to be implemented in a stepwise and modular approach and to be flexible enough to handle diverse user needs. Having been established earlier, the basic designs of the CALFIN and PACFIN systems have been completed, implementation is progressing, and additional modules are in various stages of development. The basic elements of WPACFIN, have been established thus allowing implementation to begin in a stepwise and modular fashion. The design and implementation steps will be described in greater detail in a separate WPACFIN planning document, although specifics will evolve as user and management needs become better known.

The purpose of this paper is to describe some of the functional aspects of WPACFIN and the current status of the system. The discussion will include an identification of the organizational components of WPACFIN, descriptions of the hardware and software configurations, general scenarios for data flow and data base design, and the current activities and status of WPACFIN implementation.

ORGANIZATIONAL COMPONENTS

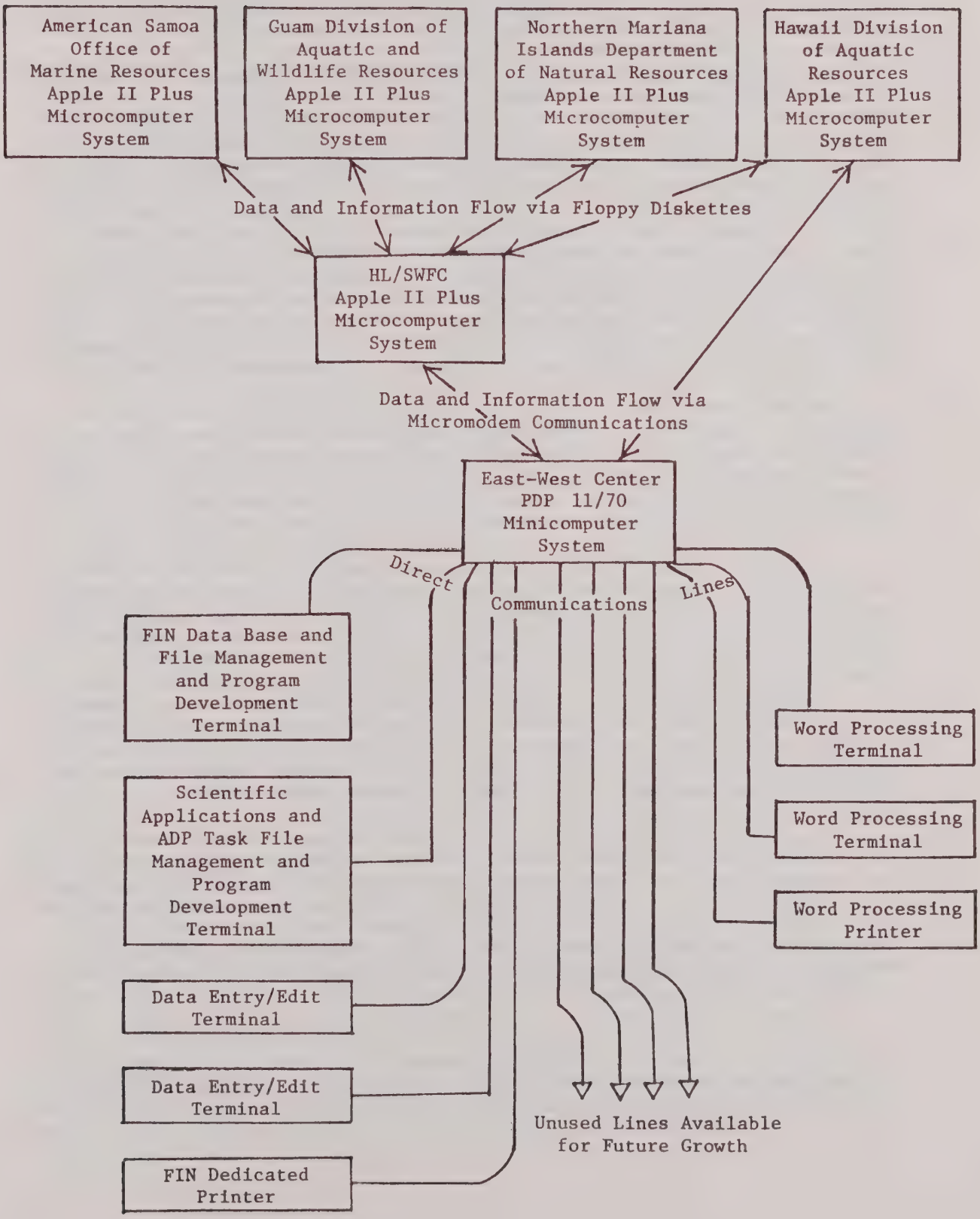
The WPACFIN refers not only to the individuals and agencies associated with all aspects of the implementation and operation of the network, but also to the integration of computer hardware, software and data bases upon which the network is based. The principal agencies involved in the initial design and implementation of WPACFIN include: the Honolulu Laboratory of the Southwest Fisheries Center, NMFS (HL/SWFC), the Hawaii Division of Aquatic Resources (HDAR), the American Samoa Office of Marine Resources (ASOMR), Guam Division of Aquatic and Wildlife Resources (GDAWR), and the Northern Mariana Islands' Department of Natural Resources (NMI/DNR). Initially, the principal users of the system will include all of the agencies listed above, and the Western Pacific Regional Fishery Management Council (WPRFMC) and the Western Pacific Program Office (WPPO) of the Southwest Regional Office, NMFS. All these agencies are participating in the design and implementation of WPACFIN to ensure that user needs are met. As the system develops and user requirements change, other agencies and users may easily become part of WPACFIN.

HARDWARE CONFIGURATION

The configuration of the computer hardware for WPACFIN may be described as a distributed computer system (Figure 1).

FIGURE 1

WPACFIN HARDWARE CONFIGURATION


American Samoa Office of Marine Resources Apple II Plus Microcomputer System
Guam Division of Aquatic and Wildlife Resources Apple II Plus Microcomputer System
Northern Mariana Islands Department of Natural Resources Apple II Plus Microcomputer System
Hawaii Division of Aquatic Resources Apple II Plus Microcomputer System
Data and Information Flow via Floppy Diskettes
HL/SWFC Apple II Plus Microcomputer System
Data and Information Flow via Micromodem Communications
East-West Center PDP 11/70 Minicomputer System
Direct
Communications
Lines
FIN Data Base and File Management and Program Development Terminal
Scientific Applications and ADP Task File Management and Program Development Terminal
Data Entry/Edit Terminal
Data Entry/Edit Terminal
FIN Dedicated Printer
Word Processing Terminal
Word Processing Terminal
Word Processing Printer
Unused Lines Available for Future Growth

The major hardware includes a central minicomputer located in Honolulu and five microcomputers distributed among the principal agencies (HL/SWFC, HDAR, ASOMR, GDAWR, and NMI/DNR).

More specifically, the central minicomputer system consists of two components. First there is a PDP 11/70 minicomputer(1), located at the East-West Center, Honolulu, Hawaii that will be utilized on a time-share basis via hard-wired communications lines. The second component consists of four video terminals and one dedicated printer terminal located at HL/SWFC. These terminals have full access to all of the minicomputer processing power. However, for design and implementation purposes, the initial configuration identifies one terminal for WPACFIN data base management and program development functions; one terminal for scientific, file management and program development functions; and two terminals for key-to-disk data entry and edit functions. The system's dedicated printer will have a keyboard and will also be useable as a terminal. Independent of WPACFIN, the HL/SWFC is utilizing two other terminals and one other printer for word processing activities on the East-West Center's computer. These could be used for FIN processing functions should the need arise. Finally, there are four other communication lines already in place between the HL/SWFC building and the East-West Center minicomputer that can be easily connected to additional hardware to facilitate future growth.

The distributed microcomputer systems are composed of 48K Apple II Plus microcomputers with additional 16K RAM language cards, twin 5 1/4 inch floppy disk drives, numeric key pads, and clock/calendar cards. Other peripheral equipment include Epson MX-100 dot matrix printers which can print 132 characters on a line and have built-in graphics capabilities, and NEC 12 inch green screen monitors for visual display. Additionally, 4 amp voltage regulators are included with each system to minimize the problems associated with power surges and voltage fluctuations. Finally, the HL/SWFC and the HDAR microcomputer systems have DC Hayes micromodems to effect communication between the microcomputers and the PDP 11/70 minicomputer.

This hardware configuration is subject to modifications as the system grows and user needs evolve and become better defined. Future enhancements may include the possible conversion from the time shared minicomputer at the East-West Center to use of an in-house minicomputer, additional microcomputers or terminals for WPRFMC and WPPO, and possibly additional computing capabilities for HDAR and the island territories.

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(1) Reference to trade names does not imply endorsement by the National Marine Fisheries Service, NOAA.

SOFTWARE CONFIGURATION

The software that will be used to process and manage WPACFIN data can be divided into two general categories: first, commercially available ("canned") computer programs; and second, specially designed computer programs. Because of the nature of WPACFIN and the persons using the system, user-oriented, canned programs will be utilized whenever possible. When canned programs do not or can not meet the needs of the system, special applications programs will be developed and implemented. The HL/SWFC will provide all general purpose WPACFIN computer programs and will assist user components develop special purpose, WPACFIN software. However, HL/SWFC will not provide assistance to users who want special software and hardware that deviate significantly from the WPACFIN system configuration. The area of software development will be the most dynamic and evolutionary portion of the information network.

The software configuration of the initial WPACFIN is based primarily on canned program packages. The majority of local data entry, edit, summarization, report generation, and file management activities will utilize a comprehensive software package called DB Master, The Data Base Manager, and will include the newly released DB Master Utility Pak #1. Additional calculating and reporting capability will be provided by the VisiCalc 3.3 software for "spread sheet" or matrix format calculations, and by the VisiTrend/VisiPlot package for time series, trend analysis, and plotting capabilities. The software package Apple Pie/Format will provide good word processing and text editing capabilities, while DOS 3.3 Toolkit, Super Disk Copy III, and others will provide some excellent utility programs. Computer languages initially available on the microcomputer systems include Applesoft BASIC, integer BASIC, and FORTRAN. Other languages can be added in the future if indicated by user needs. Documentation will be available for each software package, and user training and user manuals will be provided by HL/SWFC. The main frame computer (the PDP 11/70 at the East-West center) has an excellent selection of utility, file management, text editing, data entry, edit and retrieval programs. Also, most commonly used computer languages are available. File and system backup and security are also excellent.

As development of WPACFIN progresses and user needs become better defined, additional applications programs will be written to meet new data and information needs. User needs relating to three categories of data processing will spawn the greatest number of new applications programs. These categories include local data edit, local data summarization and report generation, and main frame data base query. By nature of the work involved, design and implementation of applications software will be a continuously evolving and time consuming function.

DATA AND INFORMATION FLOW

The WPACFIN has been designed to provide computer support and a communication network to existing fisheries agencies and to utilize and develop the expertise within these agencies for data collection and processing activities. Data collection, entry, and edit will be performed by each island territory agency using the microcomputer systems and software already described (Figure 2). At designated intervals, depending on data volume and priority, copies of the edited data on diskettes will be mailed from the field to HL/SWFC. Once received, the data will be cataloged and transmitted, via the HL/SWFC micromodem communications link, to the proper data bases on the East-West Center PDP 11/70 computer. The data will then be available for summarization and report generation. The integration of data on the main frame computer, and the extra computing power of this machine will facilitate summarization of much larger volumes of data than would be possible or practical on the microcomputer systems. If user needs dictate, data summarizations may be transmitted from the main frame computer to Apple II Plus diskettes for distribution back to the field for local use. This capability completes the data and information communications cycle.

The data flow scenario for HL/SWFC and HDAR follows the same general logic, but is somewhat more complex because these agencies have significantly more data and, therefore, more need for additional computer support than any of the island territory WPACFIN components. Figure 3 depicts the various levels of interaction possible between HL/SWFC and HDAR for accomplishing the transfer of data and information collected and maintained by the agencies. It remains the responsibility of the collecting agency to ensure that all data made available to other users are accurate and free of errors. Figure 3 shows three levels of data entry, historically a problem area, for each agency. As mentioned previously, the HDAR microcomputer system includes a micromodem for direct communication with the PDP 11/70. This direct link capability, via telephone lines, will enable them to utilize the extra computing power of the PDP 11/70 minicomputer to more efficiently perform many of their data entry and edit activities. It will also eliminate the step of data passing through the HL/SWFC microcomputer before being available on the main frame computer. Figure 3 also depicts the many communication links available between the agencies for transfer of automated data and information.

FIGURE 2

ISLAND TERRITORY
DATA AND INFORMATION FLOW

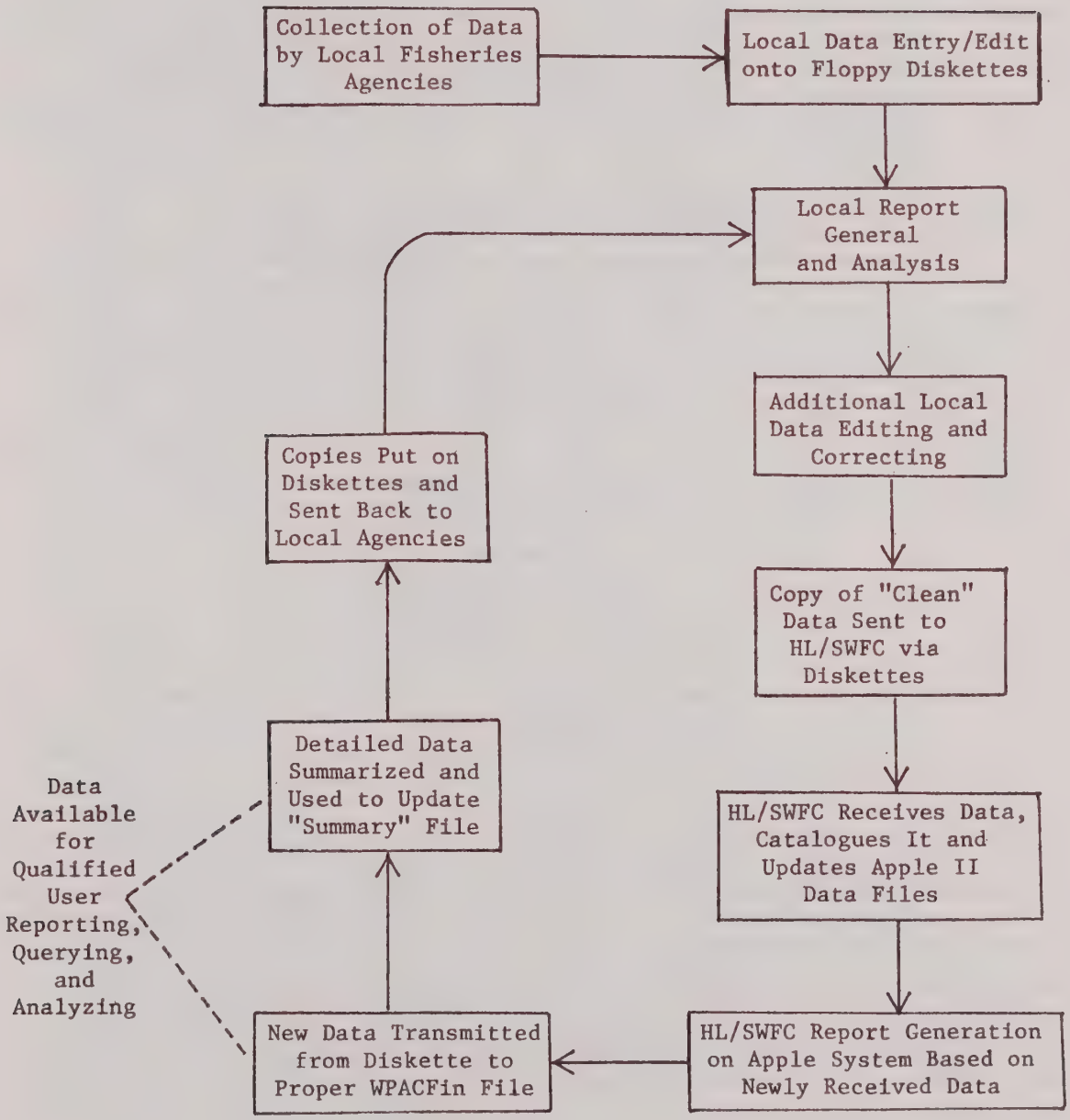
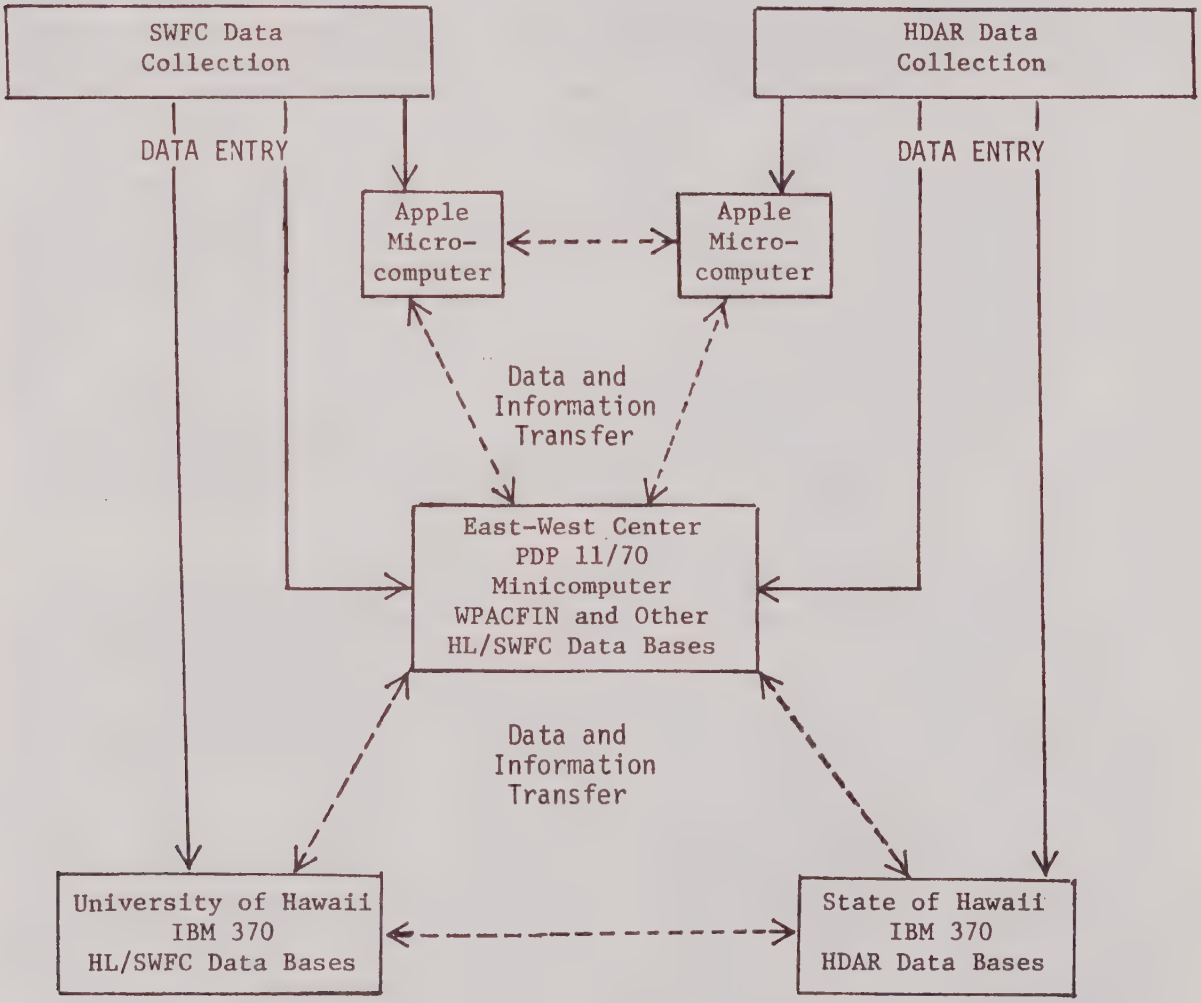

Collection of Data by Local Fisheries Agencies
Local Data Entry/Edit onto Floppy Diskettes
Local Report General and Analysis
Additional Local Data Editing and Correcting
Copy of "Clean" Data Sent to HL/SWFC via Diskettes
HL/SWFC Receives Data, Catalogues It and Updates Apple II Data Files
HL/SWFC Report Generation on Apple System Based on Newly Received Data
New Data Transmitted from Diskette to Proper WPACFin File
Detailed Data Summarized and Used to Update "Summary" File
Copies Put on Diskettes and Sent Back to Local Agencies
Data Available for Qualified User Reporting, Querying, and Analyzing

FIGURE 3

SWFC AND HDAR
DATA AND INFORMATION FLOW



DATA BASE DESIGN

The organization and structure of the data base system will reflect the nature of the unique fisheries problems and data collection systems of each of the island components of WPACFIN, but will also, as much as possible and practical, standardize the use of data elements, measurements, and data formats. It is recognized that the island agencies included in WPACFIN are separated by vast distances and that local circumstances may vary greatly with regard to their fisheries as well as to the sophistication, or even existence, of data collection systems.

It is currently envisioned that data bases identified in each island component will be developed and managed as separate entities, and where possible, will be summarized for incorporation into broader scoped, island-integrated data bases. For example, if each island component has a data base providing daily landings by species, then each of these data bases would be maintained as a separate entity, but data formats would be standardized as much as possible. Additionally, daily records could be summarized on a monthly basis and stored in another data base containing landings from all island areas. This scenario can be expanded to include other types of fisheries data, and therefore generally describe the data base structure of WPACFIN.

SPECIFIC GOALS AND ACTIVITIES

It should be emphasized that implementation of WPACFIN is a major undertaking that requires an unprecedented level of coordination and cooperation among the various governmental components. Implementation will require changes by all of the agencies involved, and these changes must be well planned and cooperatively agreed upon before being implemented. Full implementation of WPACFIN will require a firm committment to the system by all participants. The SWFC is committed to this project and has provided funds for it. It is the general philosophy of FIN to use these funds to upgrade existing data collecting and processing systems and implement new systems in such a way that the existing fisheries agencies will be capable of maintaining the systems without continuous federal funding. However, if a system improvement requires a local agency to perform activities beyond its financial capabilities, additional FIN funding may be made available.

Several general problem areas require consideration and resolution through mutual agreement before WPACFIN can be entirely implemented. These activities include:

1. Identify specific data needs for each island component and develop plans for collecting and processing the data.

2. Identify fishery management data needs and develop data collecting and reporting mechanisms to meet these needs.

3. Establish integrity and continuity of the data collecting and processing systems, and the data and information transfer mechanisms.

4. Designate qualified users of the system.

5. Finalize agreements of data exchange and confidentiality.

A number of specific activities in the implementation of WPACFIN have already been accomplished, are underway at this time, or will be started soon. A brief description of some of these follows:

1. Procurement of the five microcomputer systems was completed in late November 1981 and their installation completed by early February 1982. The microcomputer systems were installed in the following order, HL/SWFC September 29, 1981, HDAR on October 30, 1981, ASOMR on December 14, 1981, GDAWR on January 29, 1982, and NMI/DNR on February 3, 1982. Specific detailed training on data and file management techniques, hardware operation, care and maintenance, and DB Master and other software was provided to agency personnel in each of the island territories where personnel had no previous computer experience. Training of HDAR personnel was less extensive due to their previous computer experience and alternate implementation methodologies. Continued user support and additional training will be provided to all WPACFIN components on an as needed basis.

2. A contract for main frame computer services has been signed with the East-West Center. The communications cable has been installed between the HL/SWFC and East-West Center and all terminals have been connected.

3. Identification and description of historical data available in American Samoa, NMI, and Guam have been accomplished under the WPRFMC Historical Data Compilation Project. Individuals who worked on that project are working closely with HL/SWFC to ensure a coordinated transition from that project to WPACFIN implementation. Additional WPRFMC programmatic funds have been requested to continue funding the individuals involved in this project thus ensuring continuity between the data compilation project and WPACFIN implementation.

4. A "System Study" of the HDAR data collecting and processing procedures is continuing. By necessity, the study schedule has been revised because of the impact of HDAR priorities. Nevertheless, progress is being made not only in terms of the study but also in HDAR's ongoing effort to

improve its data collecting system. A draft report is targeted for completion in April and a final report is scheduled by June 1, 1982.

5. Plans are being formulated and discussed for establishing a WPACFIN Data Goals Committee to be comprised of upper management personnel from each of the major WPACFIN agencies. The Data Goals Committee will be the functional unit deciding what specific projects and data collection systems should be undertaken in each of the island areas to establish the information network. The Data Goals Committee will appoint a Technical Subcommittee composed of technical applications personnel from each of the major WPACFIN components. This subcommittee will deal with the technical and daily operational aspects of WPACFIN to ensure that user information needs are met.

6. A contract for the collection of tuna logbook and length frequency data has been awarded to ASOMR and is expected to be a continuing project. Some improved methods of data handling have been planned and implemented since the installation of the microcomputer system in American Samoa.

7. Meetings have been held with management personnel from all of the WPACFIN major components, and general agreements reached and committments made regarding the importance and direction of system implementation. An Agreement of Understanding between HDAR and SWFC on the cooperative implementation of WPACFIN was signed in May 1980. Similar areements have been drafted for American Samoa, Guam, and NMI and may be expected to be signed in the near future.

8. Data bases have been established in American Samoa, Guam, and NMI for the automation of historical catch data and certain related fisheries data.

CONCLUSION

In this preliminary description of WPACFIN, the basic configuration of the network has been described including the agencies cooperating in the endeavor, the hardware and software components, and the data communication links. As mentioned in the Introduction, greater detail will be provided in a separate planning document; however, the design of WPACFIN will evolve with the data needs of the users.

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THE 1976-78 STUDIES OF THE KAILUA-KONA, HAWAII, BILLFISH FISHERY PART I COMMERCIAL/RECREATIONAL COMPONENT

MAR 2 1 1982
National Marine Fisheries Service
2570 Dole Street
Honolulu, Hawaii

March 1982

INTRODUCTION

This report is the first of three presenting the major findings of a series of surveys undertaken in 1976-78 on the Kailua-Kona, Hawaii, billfish fisheries. The present report contains information on both commercial and recreational fishers residing in Kailua-Kona. The two reports to follow will present information on charter boat operators and their customers in the Kailua-Kona area.

In July 1977, Research Associates Inc. submitted a report entitled "A study of bio-economics and optimal management criteria for utilization of Pacific billfish" to the Southwest Fisheries Center, Honolulu Laboratory of the National Marine Fisheries Service (NMFS). This report was followed in December 1977 and May 1978 by reports on additional surveys, also performed by Research Associates. These surveys concentrated on the Kailua-Kona district of the island of Hawaii.

Although the data collected by these surveys have been used in fisheries management planning, the reports have not been readily accessible by the public. The results of these studies were partially reported by Adams[1] and in an extrapolation of these results prepared by Cooper and Adams in November 1978.[2] The results were also used by Adams in estimating the "value" of recreational fishing.[3]

The Fishery Management Research Task has prepared this edited and condensed version of the Research Associates reports in anticipation of further work on the charter boat fishery in Hawaii and of studies on recreational fishing "values." The original reports are still available at the library of the Honolulu Laboratory.

Because the reports were prepared under contract, the statements, findings, conclusions, and recommendations do not necessarily reflect the views of the NMFS. Since the contractor calculated averages and rates based on pounds and arbitrary pound-categories, we have not converted to kilograms to avoid introducing biases and cumbersome nomenclature.

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[1]Adams, M. F. 1978. Alternative estimates of net economic benefits for billfish-tuna recreational-commercial fishermen in Kailua-Kona, Hawaii. Southwest Fish. Cent. Admin. Rep. 18H, 1978, 9 p. Southwest Fish. Cent., Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 96812.

[2]Cooper, J. C., and M. F. Adams. 1978. Preliminary estimates of catch, sales, and revenue of game fish for the fishery conservation zone around the main Hawaiian Islands, by types of troll and longline vessels and by species, 1976. Southwest Fish. Cent. Admin. Rep. 24H, 1978, 10 p. Southwest Fish. Cent., Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 96812.

[3]Adams, M. F. 1980. A multispecies household production analysis of recreational fishing with dispositional benefits. Southwest Fish. Cent. Admin. Rep. H-80-5, 21 p. Southwest Fish. Cent., Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 96812.

GENERAL APPROACH

Three complementary surveys were employed to accomplish the objectives of the study:

Two hundred personal interviews with small boat owners engaged in recreational and commercial fishing in the Kailua-Kona area;

Personal interviews with charter boat operators conducting business in the Kailua-Kona area; and

Personal interviews with representatives of government agencies, commercial fish brokers, fishing organization officers, and charter organization managers who were directly concerned with fishing activities in the Kailua-Kona area.

A personal interview approach was selected in order to gather the most complete and accurate information from respondents. This method offered the opportunity for interviewers to develop rapport with respondents and reassure them about the goals of the study and the confidentiality of the information gathered. It also served to encourage a higher response rate and decrease the number of inappropriate responses and "no-answers" to survey questions.

SURVEY RESULTS

Sampling

The sampling frame for this survey consisted of a computerized listing of registered Kona district boats provided by the Harbors Division of the State Department of Transportation. Research Associates requested a vessel listing of all motor-propelled boats, 14 ft or greater in length, registered to owners who resided in certain North and South Kona areas specified by the NMFS (zip codes 96704, 96725, 96726, 96740, 96750). Owners of fishing vessels less than 14 ft in length were excluded from the survey because it was not considered likely that they would engage in trolling and handlining in open-ocean waters.

The Harbors Division computer listing contained names of owners and registra- tion information about 622 boats identified as being appropriate to the sample request. A review of the listing, however, indicated certain errors requiring correction. A few of the boats listed were located on islands other than Hawaii, some were very large boats used for tourist cruises, and other boats were listed more than once. The final corrected sampling frame provided the names of 577 boat owners in the Kailua-Kona area.

Of these, 200 boat owners were actually interviewed. People were interviewed only if they fished for certain species--marlin (black marlin, blue marlin, striped marlin, shortbill spearfish, and sailfish), ono (wahoo), ahi (yellowfin or bigeye tuna), aku (skipjack tuna), and mahimahi (dolphinfish). Field interviewing began the last week of November 1976 and ended the first week in January 1977. The sample population was <u>not</u> stratified by whether the boat owners considered themselves "commercial" or "recreational," although information was collected which would allow such post-classification.

This sample was estimated to comprise about 50% of the total number of vessels fishing the Kailua-Kona area at the time. (These people were re-interviewed in 1977, and both sets of data are available in tabular and computerized form from the Honolulu Laboratory.) The questionnaire is appended to this report.

The results of interview attempts were as follows:

	Number	Percent
Interview completed	200	43.6
Respondent could not be reached*	140	30.5
Respondent does not fish	51	11.0
Respondent does not fish for species or interest	31	6.8
Respondent refused interview	18	3.9
Boat no longer owned	11	2.4
Inappropriate listing - canoe or sailboat owned	8	1.7
Total sample	459	100.0

*Included were boat owners who had moved to another area of Hawaii or off the island, persons traveling, ill, or hospitalized, and persons without a telephone whose place of residence could not be determined.

Description of the Fleet

1. The average boat length of Kona fishing vessels surveyed was 19 ft. A significant majority (73%) of the boats were powered by an outboard engine with an average horsepower of just over 100. Sixteen percent had outboard/inboard engines and 10% had inboards.

2. More than 70% of all fishermen had owned their boats less than 5 years. The mean number of years of ownership of respondent's present boat was 3 years.

3. The average boat cost at the time of purchase was $5,650. Perceived average value at the time of the interview was $6,220, for an average increase in boat value of $570.

4. Only 13% of all owners moored their boats at a harbor. A plurality of those (45%) used Honokahou; the remainder trailered their boat to a launching location. The most popular launching site was Keauhou, with 50% using that ramp, followed by Honokahou (36%).

The following tables present responses to questions in the commercial and recreational fishing questionnaire (see Appendix). The survey question and its number precede each table.

What is the length of your boat?

Length	Percent
14-15 ft	6
16-17	32
18-19	35
20-21	13
22-23	3
24-25	3
26-29	3
30-34	3
35 ft or more	2
Average length of boat	19 ft
BASE: Total commercial/ recreational fishermen	(200)

[Survey question 1.]

What is the horsepower of your engine?

Horsepower	Percent
Less than 25	3
25-49	7
50-74	26
75-99	25
100-149	21
150-199	8
200 or more	9
No answer	1
Average horsepower of boat	107 h.p.
BASE: Total commercial/ recreational fishermen	(200)

[Survey question 7a.]

How many years have you owned your present boat?

Number of years	Percent
Less than 1	11
1	21
2	21
3	17
4	11
5	7
6-8	8
More than 8 years	4
Average number of years owned present boat:	3 years
BASE: Total commercial/ recreational fishermen	(200)

[Survey question 2.]

What was the cost of the boat when it was purchased?

Cost of boat	Percent
Less than $500	3
$500-$999	7
$1,000-$1,999	12
$2,000-$2,999	12
$3,000-$3,999	14
$4,000-$4,999	6
$5,000-$5,999	14
$6,000-$6,999	11
$7,000-$7,999	4
$8,000-$9,999	5
$10,000 or more	10
No answer	2
Average cost of boat:	$5,650
BASE: Total commercial/ recreational fisherman	(200)
[Survey question 3.]	

What is your usual launching location?

Response	Percent*
Keauhou	50
Honokahou	36
Kailua-Kona	8
Other	18
No answer	1
BASE: Commercial/recreational fishermen who trailer their boat to a launching site	(173)
[Survey question 66.]	

*Total percentages exceed 100% because multiple responses were accepted.

Fishing Practices

Eighty percent of the population surveyed used their boat only for fishing. Another 18% used it mainly for fishing or equally for fishing and other uses. Only 2% said they rarely used their boat for fishing. Over the entire sample, an average of 93% of all boat-use time was spent on fishing.

Overall, the average number of deep-sea fishing trips taken annually was 69. Just under half the population (47%) took fewer than 30 open-ocean fishing trips in 1976. At the upper end, nearly one-quarter of those interviewed (22%) went out 100 times or more a year.

Although about 12% of those interviewed usually fished alone and another 9% fished with four or more people aboard, the usual number of persons per trip was two (47%). Another 31% usually fished with three persons aboard the boat.

Over the entire sample population, 7 hours was the average duration of fishing trips. Only 14% said they usually fished for less than 6 hours per day and 17% for 10 hours or more.

Questions were asked for fishing activity over the past year from December 1975 to the time of the interview in December 1976 or January 1977.

How many boat trips did you take into the open ocean for the purpose of fishing for marlin, ono, ahi, aku, or mahimahi?

Number of trips (year from December 1975)	Percent
Less than 10	18
10-19	14
20-29	15
30-39	9
40-59	9
60-79	11
80-99	2
100-199	11
200-299	8
300 or more	3
Average number of trips:	69 trips
BASE: Total commercial/ recreational fishermen	(200)

[Survey question 10.]

On those trips, what is the average or usual number of persons aboard the boat, including yourself?

Response	Percent
Respondent only	12
2 people	47
3 people	31
4 people	8
5 people	1
No answer	1
Average number of people:	2 people
BASE: Total commercial/ recreational fishermen	(200)

[Survey question 11.]

Thinking of those fishing trips into the open ocean, what would be the average or usual duration of the fishing trip? About how many hours did you stay out each time?

Number of hours [per trip]	Percent
3 or less	2
4	5
5	7
6	28
7	11
8	24
9	6
10	12
More than 10	5
Average number of hours	7 h
BASE: Total commercial/ recreational fishermen	(200)

[Survey question 12.]

Fish Catch, Disposition, and Earnings

More Kona fishermen caught ono (wahoo) than any other species, followed by ahi (yellowfin tuna). Eighty-three percent of those interviewed caught at least one ono and 80% caught ahi. Mahimahi (dolphinfish) and aku (skipjack tuna) were caught by about 70% of the fishermen interviewed. Aku and ahi were caught in the greatest numbers.

Billfish were caught infrequently by this population, probably because they have far less commercial value than the other fishes and therefore are fished for less often. Only 8% caught striped marlin, 12% caught sailfish and black marlin, 20% caught shortbill spearfish, and 40% caught blue marlin.

The mean number caught and mean number of pounds caught of each species is described below. It should be emphasized that this average or mean is based on those catching one or more of that species and, therefore, cannot be projected to the total population.

Annual catch	Average number caught	Average pounds caught	Percentage of fishers who catch species
Ono	18	560	83
Ahi	35	3,290	80
Aku	52	260	70
Mahimahi	8	200	70
Blue marlin	5	1,200	40
Black marlin*	5	1,670	12
Striped marlin	2	280	8
Shortbill spearfish	3	100	20
Sailfish	1	70	12

[Survey question 13.]

*The NMFS biologists have found a much higher percentage of blue marlin compared with black marlin, suggesting that some marlin may be misidentified in this survey.

For each species of fish caught, all boat owners in the sample were asked how many pounds they kept for their own use or gave away to family and friends versus how many pounds they sold.

The table below shows the estimated mean number of pounds in each of those categories (based on data reported by those who caught one or more of that species during the year). Ahi was, by far, the leader in pounds sold by percent of total catch, with only about 1 pound retained for the respondents' own use for each 6 pounds sold. Just over 70% of the mahimahi catch and about 65% of the blue marlin catch was sold. Aku and black marlin, as shown, were more likely to be kept than sold. With respect to ono, striped marlin, spearfish, and sailfish, the number of pounds kept and the number of pounds sold are about equal.

Annual catch	Pounds kept/ given away (mean)	Pounds sold (mean)	Pounds caught (mean)
Ono	250	300	560*
Ahi	500	2,970	3,290
Aku	180	70	260
Mahimahi	60	150	200
Blue marlin	440	780	1,200
Black marlin	1,140	580	1,670
Striped marlin	140	140	280
Shortbill spearfish	50	50	100
Sailfish	30	30	70
[Survey question 13.]			

*The species means do not always sum exactly to the total mean because the algorithm (for all means) used data that had been rounded and then assigned to graduated group intervals.

Mean earnings from the sale of fish ranged from a low of $20 for those catching sailfish to almost $3,000 for those catching ahi. As shown in the table below, ahi is by far the most important commercial catch, in terms of pounds caught and dollars earned. Mahimahi ranks highest in price paid per pound at an average value of $1.95, followed by ahi at $1.00 and ono at $0.87. The least valuable catch, on a per-pound basis, is blue marlin at an estimated mean of $0.23.

Annual catch	Pounds sold (mean)	Earnings (mean)	$ per pound (mean)
Ono	300	$ 260	$ .87
Ahi	2,970	2,970	1.00
Aku	70	50	.71
Mahimahi	150	290	1.95
Blue marlin	780	180	.23
Black marlin	580	190	.33
Striped marlin	140	50	.36
Shortbill spearfish	50	40	.80
Sailfish	30	20	.67
[Survey question 13.]			

The final table in this series provides information about personal earnings from the sale of all species of fish included in the study. Overall, the estimated mean income from combined sales was $2,939. This figure is based upon earnings data from all boat owners interviewed and the mean, therefore, takes into account the 31% of the population who had no income from the sale of fish. The estimated mean of $2,939 is, then, projectable to all boat owners in the sample population.

Annual catch	Average number caught	Average pounds caught	Average pounds kept/ given away	Average pounds sold	Average earnings
Ono	18	560	250	300	$ 260
Ahi	35	3,290	500	2,970	2,970
Aku	52	260	180	70	50
Mahimahi	8	200	60	150	290
Blue marlin	5	1,200	440	780	180
Black marlin	5	1,670	1,140	580	190
Striped marlin	2	280	140	140	50
Shortbill spearfish	3	100	50	50	40
Sailfish	1	70	30	30	20

BASE: Variable--those catching one or more of each species.
[Survey question 13.]

In summary, for the 200 people interviewed as a whole:

What were your total annual earnings from the sale of _____?

Species	Average earnings
Ono	$ 217
Ahi	2,376
Aku	35
Mahimahi	203
Blue marlin	71
Black marlin	23
Striped marlin	4
Shortbill spearfish	8
Sailfish	2
Total	$2,939
BASE: [Survey question 13f.]	(200)

Expenditures

The following set of tables presents information about the expenditures of boat owners for the calendar year 1976. It is of particular interest to note that overall, the mean annual expenditure of boat owners interviewed exceeded mean earnings by about $1,800.

Mean annual expenditure	$4,740
Mean annual earnings	2,939
Mean loss	1,801

[Survey question 14.]

Among the total sample, the largest expenditure was for fuel and oil used by the boat and for the transporting-vehicle (for trailered boats) ($1,248). This was followed by average boat payment costs of $649, fishing tackle purchases amounting to $527, and expenses of $471 in engine repairs.

The following table presents the annual mean for all expense items included in the survey:

Expense item	Mean annual expenditure
Boat/vehicle fuel and oil	$1,248
Boat payments	649
Fishing tackle purchase	527
Engine repairs	471
Food and beverages	258
Vehicle payments	197
Fishing tackle repairs	175
Ice	168
Live bait	148
Boat insurance	136
Electronic equipment repairs	117
Vehicle insurance	106
Vehicle repairs	93
Share of fish	84
Hull repairs	75
Tournament fees	29
Licenses and fees	23
Salaries	21
Commissions	19
Mooring fees	9
Club or association fees	8
Other expenses	179
All expenditures combined	$4,740
BASE:	(200)

[Survey question 14.]

When respondents were asked about "other expenses" not specifically mentioned in the questionnaire, the most frequently cited costs were for trailer acquisition or repair, the purchase of a new primary or auxiliary engine, and radio acquisition or repair. As shown, the mean expenditure for "other expenses" was $179.

Finally, in the general area of expenditures, fishermen were asked first, if they personally did any repairs and maintenance on their own boat, transporting vehicle, or other equipment, and if so, about how many hours per year they worked on it. Eighty-eight percent said they did at least some of their own maintenance. The mean number of hours spent annually was 108, or about 14 working days.

Personal Characteristics of the Sample Population

Ninety-eight percent of the boat owners interviewed were males and the mean age of all respondents was 44 years. Thirty-seven persons (or about 18% of the sample) listed commercial fishing as their primary occupation, although 70% had a commercial fishing license. A plurality (28%) of those interviewed were working in trades or laborer occupations. The estimated mean income of respondents was about $13,500; 11% of the population had an annual income of $5,000 or less, and 5% earned over $30,000.

Among those who said they had income beyond that from their primary occupation, the sale of fish was by far the major source. More than half the sample realize secondary income from commercial fishing. Another 34 persons had secondary income from occupations other than commercial fishing; mentioned most often were ranching or farming (12 persons) followed by real estate sales and investments (8 persons). Most (86%) of those who have secondary incomes earn $5,000 or less annual from this part-time occupation.

Seventy-three boat owners, or about 37% of those interviewed, belong to a trolling club.

What is your primary income-producing occupation?

Occupation	Percent
Trades	28
Commercial fishing	18
Real estate/sales/investments	8
Technical	7
Supervisory/managerial	6
Tourism	6
Ranching/farming	6
Professional	4
Civil service	3
Retired	11
Other	3
BASE: Total commercial/recreational fishermen	(200)

[Survey question 17.]

Finally, are you a member of a trolling club?

Response	Percent
Yes	37
No	63
BASE: Total commercial/recreational fishermen	(200)

[Survey question 20.]

Characteristics of the Fleet by Whether Respondents Had a Commercial Fishing License or Not

This section of the report describes responses to important questionnaire variables by whether the boat owner had a commercial fishing license or not.

Boat owners with commercial licenses have, overall, more money invested in their boats. At the time of purchase, there was a mean difference of about $1,700 in the initial cost between the two subgroups. At the time of the interview, persons with a commercial license estimated the mean value of their boat as $6,780 versus $4,930 for non-licensees. The percent of increase in the boat's value from date of purchase remains nearly constant for both segments, however, with a mean increase of approximately 10% overall.

Commercially-licensed boat owners were significantly more likely to use their boat entirely for fishing. Eighty-eight percent of these said all of their boat-use time was spent fishing while only 61% of unlicensed boat owners without commercial fishing licenses said their boat was used entirely for fishing.

The difference in engine horsepower between the two groups is minimal. Mean horsepower for commercial licensees was 111 h.p. and for non-licensees, 98 h.p.

Fishermen with commercial licenses make, on the average, more than twice as many fishing trips annually than those without licenses, and the duration of their trips tend to be somewhat longer:

	Total	Have commercial license	Do not have commercial license
Number of trips annually (mean)	69	82	38
Number of hours at sea per trip (mean)	7.5	8	7

All species of fish included in the study were caught by a higher percentage of license holders than non-licensees. Most notable differences were in percent catching ahi (88% of the commercial fishermen caught, 62% of the non-commercial fishermen caught), mahimahi (77% versus 54%), and blue marlin (47% versus 23%).

The average number of each species caught did not vary greatly between the two subgroups, except in the case of ahi, where those with a commercial license caught about three times as many, on the average, as those without a license.

Average pounds caught corresponds to average number caught, with the greatest variance between licensees and non-licensees being in pounds of ahi caught. Commercially-licensed fishermen caught more than three and one-half times as many pounds of ahi.

As would be expected, those with a commercial license sold the majority of their fish catch (except in the case of aku, which is often used as a baitfish) and those without a license kept or gave away the majority of their catch. By percentage of the total pounds caught of each species, mahimahi was the fish most often sold by non-licensees, followed by ahi.

Income from fish sales was many times higher for those with a commercial license. The annual mean for commercially-licensed fishermen was $4,098 versus a mean of $286 for those without a license.

Total annual expenditures for commercially-licensed fishermen was almost three times that of non-licensed fishermen. This is not surprising in light of other related findings about license holders, such as: they had more expensive boats with somewhat larger engines, went fishing more often, stayed out longer, and caught more fish. All of these characteristics and behaviors would necessarily result in a greater expenditure in nearly all categories. In addition, they were far more likely to keep records, which leads to recall of cost items others may have overlooked.

A comparison of earnings and expenditures of both subgroups shows that each had boat and fishing expenditures in excess of earnings from fish sales. The mean difference, however, was less for commercially-licensed fishermen ($1,821) than for non-licensed respondents who spent an average of more than $2,000 per year and had average earnings of less than $300. Mean earnigs for unlicensed fishermen should be interpreted with caution, however, since the majority (63%) of respondents in that subgroup sold no fish at all.

Finally, commercially-licensed boat owners spent close to twice as many hours annually in personally maintaining their vessels. The mean number of maintenance/repair hours for licensed fishermen was 112 per year; for unlicensed fishermen it was 57 hours.

Annual expenditures	Total	Have commercial fishing license	Do not have commercial fishing license
Boat payments	$ 649	$ 833	$ 230
Vehicle payments	197	241	98
Mooring fees	9	10	5
Boat/vehicle fuel and oil	1,248	1,557	542
Engine repairs	471	571	244
Hull repairs	75	98	25
Electronic equipment repairs	117	130	86
Fishing tackle repairs	175	225	61
Vehicle repairs	93	116	41
Fishing tackle purchase	527	649	249
Live bait	148	205	18
Ice	168	227	35
Boat insurance	136	151	103
Vehicle insurance	106	111	94
Licenses and fees	23	27	16
Salaries	21	30	--
Commissions	19	27	--
Share of fish	84	117	8
Food and beverages	258	296	170
Club or association fees	8	10	5
Tournament fees	29	32	21
Other expenses	179	256	5
All expenditures combined:	4,740	5,919	2,056
BASE:	(200)	(139)	(61)

[Survey question 14.]

What was the total pounds of _____ caught?

	Annual average pounds caught		
Species	Total	Have commercial fishing license	Do not have commercial fishing license
Ono	468	445	504
Ahi	2,632	3,388	910
Aku	179	197	138
Mahimahi	140	169	65
Blue marlin	474	585	232
Black marlin	200	124	375
Striped marlin	20	22	16
Shortbill spearfish	20	20	24
Sailfish	8	10	3
BASE:	(200)	(139)	(61)

[Survey question 13c.]

What were the total earnings from the sale of _____ ?

Species	Annual average earnings		
	Total	Have commercial fishing license	Do not have commercial fishing license
Ono	$ 217	$ 265	$ 94
Ahi	2,376	3,353	162
Aku	35	49	--
Mahimahi	203	277	22
Blue marlin	71	103	7
Black marlin	23	32	--
Striped marlin	4	5	--
Shortbill spearfish	8	11	1
Sailfish	2	3	--
Total for all species	$2,939	$4,098	$286
BASE: [Survey question 13f.]	(200)	(139)	(61)

Characteristics of the Fleet by Level of Earnings from Sale of Fish

This section describes the characteristics of the sampled population cross-tabulated by the level of earnings the respondents received from the sale for fish.

The majority of the boat owners interviewed (62%) earned less than $1,000 during 1976 from the sale of fish. Forty-eight persons (24%) earned more than $1,000 but less than $5,000, and about 15% (29 persons) earned $5,000 and above.

There is a positive correlation between boat length and level of earnings. There is, however, a mean difference of only 2 ft in boat length between the lower and the higher earnings levels.

Boat owners with higher fish sale earnings tended to have a more expensive boat. The following condensed table shows the mean purchase price and current value of vessel by level of income from sale of fish:

	Annual income from sale of fish		
	None to $999	$1,000-$4,999	$5,000 and over
Cost of boat when purchased (mean)	$5,230	$6,070	$6,720
Current value of boat (mean)	5,580	7,010	7,610

Persons with higher earnings also had, on the average, an engine with greater horsepower. Boat owners at the lower income level had an average horsepower of 98; at the moderate income level, average horsepower was 120; and at the higher income level, average horsepower was 124 h.p.

Not surprisingly, a strong correlation exists between the number and duration of fishing trips and income from the sale of fish. The following condensed table provides the mean for these fishing practice variables cross-tabulated by the income from sale of fish:

		Annual income from sale of fish		
	Total	None to $999	$1,000-$4,999	$5,000 and over
Number of annual fishing trips (mean)	69	30	80	212
Usual duration of trip in hours (mean)	7	6	8	9

Those in the higher income category are generally more likely to have caught at least one of each species of fish than those in the moderate and lower earnings category.

The greatest variance by the three income categories centers around ahi catch. The following condensed table presents differences in ahi catch, disposition, and earnings as related to annual fish sale income.

	Annual income from sale of all species		
Ahi	None to $999	$1,000-$4,999	$5,000 and over
Mean number caught	5	22	134
Mean pounds caught	523	2,251	12,218
Pounds kept or given away	396	500	268
Pounds sold	129	1,198	12,510
Mean earnings	$99	$794	$12,861

Catching and selling ahi was clearly the key to realizing any substantial income from commercial fishing.

Overall, average annual expenditures coincided with categories of income from sale of fish, with expenditures rising as success in catching and selling fish increased. Mean annual expenditures for those earning 0-$999 was $2,574; for those earning $1,000-$4,999 it was $5,308; and in the highest income category ($5,000 and over) mean expenditures total an impressive $12,970.

The subgroup most likely (94%) to personally do their own boat repair and maintenance was the middle income group (those earning from $1,000-$4,999 from fish sales). With respect to annual hours spent on maintenance, the middle and high income groups spent about equal amounts of time (142/143 hours). Those earning less than $1,000 from fish sales spent about 65 hours per year working on their vessels.

Annual expenditures	Average expenditure			
	Total	None to $999	$1,000-$4,999	$5,000 and over
Boat payments	$ 649	$ 442	$ 816	$ 1,247
Vehicle payments	197	137	245	374
Mooring fees	9	7	14	2
Boat/vehicle fuel and oil	1,248	506	1,524	3,936
Engine repairs	471	238	488	1,422
Hull repairs	75	82	49	93
Electronic equipment repairs	117	116	77	182
Fishing tackle repairs	175	82	295	366
Vehicle repairs	93	73	43	264
Fishing tackle purchase	527	267	615	1,514
Live bait	148	24	111	728
Ice	168	40	150	733
Boat insurance	136	104	200	160
Vehicle insurance	106	102	80	165
Licenses and fees	23	22	26	28
Salaries and wages	21	--	7	129
Commissions	19	1	--	129
Share of fish	84	10	144	297
Food and beverages	258	141	246	763
Club or association fees	8	7	13	7
Tournament fees	29	18	56	29
Other expenses	179	155	109	402
Total expenditure	4,740	2,574	5,308	12,970
BASE:	(200)	(123)	(48)	(29)

[Survey question 14.]

What were your total earnings from the sale of _____?

Species	Annual average earnings			
	Total	None to $999	$1,000-$4,999	$5,000 and over
Ono	$ 217	$ 51	$ 249	$ 846
Ahi	2,376	99	794	12,861
Aku	35	3	43	171
Mahimahi	203	170	132	441
Blue marlin	71	7	126	256
Black marlin	23	4	15	112
Striped marlin	4	--	3	11
Shortbill spearfish	8	1	16	20
Sailfish	2	*	3	7
Total	$2,939	$335	$1,381	$14,725
BASE:	(200)	(123)	(48)	(29)

[Survey question 13f.]

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STUDY OF BIO-ECONOMICS AND OPTIMAL MANAGEMENT CRITERIA FOR UTILIZATION OF PACIFIC BILLFISH

MODULE I

PREPARED FOR:

NATIONAL MARINE FISHERIES SERVICE
HONOLULU LABORATORY

BY:

RESEARCH ASSOCIATES

JULY 1977

APPENDIX

COMMERCIAL & RECREATIONAL FISHING QUESTIONAIRE

Hello, I'm _____ from Research Associates. We're working as consultants to the National Marine Fisheries Service to develop information about the value of commercial and recreational fishing to the people of the Kona Coast. Your frank and open answers will help provide the basis for a fisheries management plan which will benefit the local fishing industry here. All of your answers will be strictly confidential, of course.

Screening: For this study, we are interviewing commercial and recreational fishermen who have fished for marlin, ono, ahi, or mahi-mahi at some time during the past twelve months. Have you fished for these species during the past year?

(___) Yes (CONDUCT INTERVIEW)
(___) No (TERMINATE INTERVIEW)

Fine. First, I'd like to ask you some questions about your boat and about the kinds of fishing you do.....

Q.1 What is the length of your boat? _____ ft.

Q.2 How many years have you owned your present boat? _____ yrs.

Q.3 What was the cost of the boat when it was purchased? $_____

Q.4 What would you say is the value of the boat today? $_____

Q.5 Is your boat used entirely for fishing, mainly for fishing, about equally for fishing and other purposes, or is it rarely used for fishing?

1 (___) entirely for fishing (SKIP TO Q.6)
2 (___) mainly for fishing
3 (___) equally for fishing and other uses
4 (___) rarely for fishing

Q.5a About what percent of your total boat-use time is spent on fishing? _____%

Q.6 Is your boat trailered to the pier, or is it moored?

1 (___) trailered
2 (___) moored

Q.6a At what pier is it moored?

1 (___) Keauhou
2 (___) Kailua-Kona
3 (___) Honokahou
4 (___) Other (specify) _____

Q.6b What is your usual launching location?

1 (___) Keauhou
2 (___) Kailua-Kona
3 (___) Honokahou
4 (___) Other (specify) _____

COMMERCIAL AND RECREATIONAL FISHING QUESTIONNAIRE

RESEARCH ASSOCIATES
DECEMBER 1976

RESPONDENT'S NAME _____

ADDRESS _____

PHONE _____

INTERVIEWER'S NAME _____

DATE OF INTERVIEW _____

LENGTH OF INTERVIEW _____

Now, we need to have some information about your fish catches for the past year. For this study, we are interested in the larger, open-ocean fish such as ono, ahi, aku, mahi-mahi, and different marlin species.....

Q.13	a. Did you catch any (name) during the past twelve months?	b. How many did you catch?	c. Total lbs. caught	d. How many lbs. did you keep for yourself or give away?	e. How many lbs. did you sell?	f. What were your total earnings from the sale of (name)?
Ono	Caught (___) Not Caught (___)					
Ahi	Caught (___) Not Caught (___)					
Aku	Caught (___) Not Caught (___)					
Mahi-mahi	Caught (___) Not Caught (___)					
Blue marlin	Caught (___) Not Caught (___)					
Black marlin	Caught (___) Not Caught (___)					
Striped marlin	Caught (___) Not Caught (___)					
Shortbill spearfish	Caught (___) Not Caught (___)					
Sailfish	Caught (___) Not Caught (___)					

(GO THROUGH QUESTIONS a, b, c, d, e, and f FOR EACH FISH LISTED)

Now, we need to have some information about your fish catches for the past year. For this study, we are interested in the larger, open-ocean fish such as ono, ahi, aku, mahi-mahi, and different marlin species.....

	a.	b.	c.	d.	e.	f.
Q.13	Did you catch any (name) during the past twelve months?	How many did you catch?	Total lbs. caught	How many lbs. did you keep for yourself or give away?	How many lbs. did you sell?	What were your total earnings from the sale of (name)?
Ono	Caught (___) Not Caught (___)					
Ahi	Caught (___) Not Caught (___)					
Aku	Caught (___) Not Caught (___)					
Mahi-mahi	Caught (___) Not Caught (___)					
Blue marlin	Caught (___) Not Caught (___)					
Black marlin	Caught (___) Not Caught (___)					
Striped marlin	Caught (___) Not Caught (___)					
Shortbill spearfish	Caught (___) Not Caught (___)					
Sailfish	Caught (___) Not Caught (___)					

(GO THROUGH QUESTIONS a, b, c, d, e, and f FOR EACH FISH LISTED)

Q.7 Does your boat have an outboard engine, an inboard engine, or an outboard/inboard engine?

1 (___) outboard
2 (___) inboard
3 (___) outboard/inboard

Q.7a And what horsepower is that? _____

Q.8 Do you currently have a commercial fishing license?

1 (___) Yes
2 (___) No

Q.9 Do you keep a boat log or other kinds of records about the following items?

	Records	No Records
Number of fishing trips	1 (___)	2 (___)
Number of persons aboard	1 (___)	2 (___)
Hours at sea	1 (___)	2 (___)
Engine time	1 (___)	2 (___)
Amount of fish caught	1 (___)	2 (___)
Boat expenditures	1 (___)	2 (___)

Now, thinking of the past twelve months.....that would be from December 1975 until the present date....

Q.10 How many boat trips did you take into the open ocean for the purpose of fishing for marlin, ono, ahi, aku, or mahi-mahi? Please check your records, if possible; if not, give us your best estimate. (FOR ALL SUBSEQUENT ANSWERS, INDICATE "E" FOR ESTIMATES AND "R" FOR ANSWERS FROM RECORDS.)

_____ boat trips

Q.11 And on those trips, what is the average or usual number of persons aboard the boat, including yourself?

1 (___) Respondent only (1 person)
2 (___) Respondent and one other (2 persons)
3 (___) Respondent and two others (3 persons)
4 (___) Respondent and three others (4 persons)
5 (___) Respondent and four others (5 persons)
6 (___) More than respondent and four others (5+ persons)

Q.12 Again, thinking of those trips into the open ocean, what would be the average or usual duration of the fishing trip? About how many hours did you stay out each time?

_____ hours

Q.15a About how many hours would you say you spent working on boat-related repairs and maintenance in the past twelve months?

_____ hours

Now, we'd like to ask you some questions for classification purposes only.....

Q.16 Which of the following categories include your age?

1 (___) 18 - 24 years
2 (___) 25 - 34 years
3 (___) 35 - 44 years
4 (___) 45 - 54 years
5 (___) 55 - 64 years
6 (___) 65 years and over
7 (___) Refused

Q.17 What is your primary income-producing occupation?

1 (___) commercial fishing
2 (___) other (specify) _____

Q.18 And what is your annual income from that occupation? (SHOW CARD)

_____

Q.19 What other, if any, sources of personal income do you have.....this would include income from the sale of fish (IF NOT MENTIONED AS THE ANSWER TO THE PREVIOUS QUESTION), income from another occupation, or State assistance from the Department of Social Services and Housing.

1 (___) no other sources of income (GO TO Q.20)
2 (___) income from sale of fish (GO TO Q.19b)
3 (___) other occupation (GO TO Q.19a and b)
4 (___) Department of Social Services and Housing (GO TO Q.19b)

a. What is your other occupation?

_____

b. How much annual income do you receive from this source? (SHOW CARD)

_____

Q.20 Finally, are you a member of a trolling club?

1 (___) Yes
2 (___) No

a. Which club is that?

1 (___) Kona Mauka Trollers
2 (___) Kona Iki Trollers
3 (___) Both of the above
4 (___) Other (specify) _____

Thank you very much for your help. I'd like to mention again that the information you have given us will be held in strictest confidence and will not be identified with you personally or with your name.

Someone from my company may telephone, however, to verify that this interview was conducted.

Mahalo!

Sex of respondent: (RECORD, DO NOT ASK)

1 (___) Male
2 (___) Female

Again, for the past twelve months....we need to ask about your expenses related to fishing for marlin, ono, ahi and mahi-mahi. Please check your records, if possible, or give your best estimate for each category.

Q.14	Item	Annual Costs
a. First, if you are making payments on your boat and/or vehicle you use to transport your boat, we would like to know what these payments have amounted to in the past year.	Boat Payments	
	Vehicle Payments	
b. (IF BOAT MOORED) What were your mooring fees?	Mooring Fees	
c. How much did you spend for boat fuel and oil? for fuel and oil for your transporting vehicle, if applicable?	Boat Fuel and Oil	
	Vehicle Fuel and Oil	
d. How much did you spend on engine repairs? repairs on the hull? repairs on any electronic equipment? fishing tackle repairs? repairs and maintenance of your transporting vehicle?	Engine Repairs	
	Hull Repairs	
	Electronic Equipment Repairs	
	Fishing Tackle Repairs	
	Vehicle Repairs	
e. What is the total amount you spent for fishing tackle, including rods and reels, lures, hooks and leaders, line, and skirts and leadheads?	Fishing Tackle	
f. How much did you spend on live bait?	Live Bait	
g. How much did you spend for ice?	Ice	
h. How much did you spend on insurance for your boat? for your transporting vehicle?	Boat Insurance	
	Vehicle Insurance	
i. What is the total amount you spent for licenses and fees, such as your excise tax license, your commercial fishing license, and your boat registration?	Licenses and Fees	
j. What is the total amount you spent on salaries, commissions, and "share-of-fish" to persons who help aboard your boat?	Salaries	
	Commissions	
	Share-of-fish	
k. How much was spent for food and beverages for you and others you may have had aboard?	Food and Beverages	
l. How much was spent for club or association fees?	Club or Association Fees	
m. How much was spent for tournament fees?	Tournament Fees	
n. Can you think of any other significant boat-related expenses you have incurred during the past year that we haven't mentioned? If so, what are they and how much did you spend?	Other _____	

Q.15 Do you personally do any of your own repairs and maintenance on your boat, vehicle, or fishing equipment?

1(___) Yes (GO TO Q.15a)
2(___) No (SKIP TO Q.16)

A SURVEY OF THE IKA-SHIBI FISHERY IN THE STATE OF HAWAII, 1980

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National Marine Fisheries Service
2570 Dole Street
Honolulu, Hawaii

WALTER N. IKEHARA

CONSULTANT

OCTOBER 1981

Final Contract Report to the National Marine Fisheries Service

Southwest Fisheries Center, Honolulu Laboratory

Contract Purchase Order no. 80-JJA-00389

PREFACE

This report was prepared under contract (Purchase Order No. 80-JJA-00389, dated 19 September 1980) by Walter N. Ikehara, graduate student, University of Hawaii. The contract objective was to collect data from the Hawaiian ika-shibi fishery. The resulting data tabulations and summarizations, and descriptions of data collecting methodology provide information on the status of the Hawaiian ika-shibi fishery through 1980 and are intended to aid future data collecting activities for this fishery. Since the report was prepared under contract, the statement, findings, conclusions, and recommendations in it are those of the contractor and do not necessarily reflect the view of the National Marine Fisheries Service.

Howard O. Yoshida
Fishery Biologist

16 April 1982

INTRODUCTION

The ika-shibi, or night handline, fishery for tunas has undergone rapid expansion in the last few years. This is due mainly to the high productivity of the method and its low capital and operating costs. Although predominantly occurring on the island of Hawaii, it has also become established on Kauai and possibly other islands in the state of Hawaii. Since the description of the fishery by Yuen (1979), based on 1973-1975 data, there have been no reports detailing the recent development and progress of the fishery.

Since there is no separate category for ika-shibi in the catch reports of the Division of Aquatic Resources, state of Hawaii, ika-shibi catch data are usually reported in the deep-sea handline category. Because the deep-sea handline category may also include catch data from the day handline and bottomfish handline fisheries, it is difficult to distinguish the ika-shibi catch. It is also possible that some of the ika-shibi catch may not be reported at all. The National Marine Fisheries Service funded this contract for the purpose of collecting descriptive data on the ika-shibi fishery in the state of Hawaii in order to assess the size of the fishery, its economic value, and its catch, for inclusion in fishery management plans for tuna and billfish species.

The results of this survey will be useful in the formulation of economic and development plans for the fishing industry in the state and in the planning of further research on the ika-shibi fishery.

METHODS

The data were collected in two ways from five principal wholesalers on the island of Hawaii and one from the island of Kauai: 1) The wholesalers who deal with ika-shibi fishermen were approached and direct access was gained to their fish records. The data I collected from these records included the date of catch, locality, and catch by species with individual fish weights and prices. 2) In some cases, I could not collect the data myself and so the data were extracted by the wholesaler, and did not always include complete records of all desired data. As a result some of the data presented in the tables represent mixtures of actual data and estimates based on similar data from other wholesalers.

The value data were incomplete from two wholesalers so the ex-vessel revenues were estimated by the following method. The mean price per pound was calculated from data from other wholesalers in the same area. The weight of each fish was multiplied by the price per pound, then summed for the entire month. The month's total value was divided by the total weight of fish for the month yielding the monthly mean price per pound. The total weight of fish for each month from the wholesaler with

missing value data was multiplied by the calculated mean price per pound resulting in the month's estimated ex-vessel revenue. This was done for each month and each species for which the wholesaler lacked value data. Note that the figures cited in Table 1 represent the ex-vessel value of the fish only and do not include the value added by the wholesalers and retailers dealing with the marketing and processing of fish caught in the ika-shibi fishery. Data were not collected from small wholesalers dealing with a few ika-shibi fishermen or from fishermen who market their catch independently as they comprise a small segment of the total ika-shibi fishery and it was difficult to collect these data.

The catch records were arbitrarily selected, with the consultation of wholesalers and fishermen, for inclusion in the ika-shibi catch data, as notations were not made as to the method by which fish were caught. The records were selected based on knowledge of the established ika-shibi fishermen and presence in the catch of species usually caught by ika-shibi fishermen, such as yellowfin tuna, albacore, swordfish, and bigeye tuna. In Hilo, on the island of Hawaii, fishermen who use the ika-shibi method do not usually fish any other way. However, along the south and west coast of Hawaii, fishermen may utilize the ika-shibi, day tuna handline, trolling, and bottom-fishing methods, depending on the season and the particular types of fish in abundance. Along the southwest coast, it seems that most tuna fishermen use the ika-shibi

method only at times when large tuna are abundant in certain areas. Some fishermen use the ika-shibi method consistently during much of the year.

Since the wholesale records do not include data on fishing effort, a stock assessment study was infeasible and there was no certainty as to which fishermen were full-time or part-time. Full-time meant that the fisherman had no other full-time job, while part-time meant that the fisherman may have another full-time job, or that less than one-half of his income came from fishing. Some indication can be obtained by examining the dates of reported catch (not presented here) assuming that full-time fishermen are more likely to fish during the week than are part-time fishermen. A large number of full-time fishermen will confirm the validity of the ika-shibi fishery as an industry.

RESULTS

The tables clearly show that the ika-shibi fishery is now considerably larger than when described by Yuen (1979). The total weight of tunas caught in 1980 was almost six times that for 1975 (887,782 vs. 154,955 kilograms). The ex-vessel revenues for tunas in 1980 was about $2.8 million compared to $327,500 for 1975, almost a ten-fold increase. Other species added about $110,000 to the total ex-vessel revenues for 1980. The species caught are listed in order of weight (Table 1) and show that yellowfin tuna is definitely the primary species

caught. What is somewhat surprising, is the considerable catch of albacore in the fishery, larger in 1980 than the bigeye tuna catch. However, in other years the bigeye tuna catch may be larger than the albacore catch, as in 1975 (Yuen, 1979). Also interesting are the appreciable catches of swordfish and large marlins, although probably smaller than the catch of the longline fleet. It is possible that some of the marlin catch, especially the striped marlin, may have been caught by ika-shibi fishermen using longlines during the off-season.

The number of fishermen listed in Table 2 is a conservative estimate of the total number of ika-shibi fishermen. In the case of one wholesaler, no data were provided as to the number of ika-shibi fishermen reporting their catch each day. No attempt was made to estimate the number of these fishermen.

Of those for which good records were available, 233 fishermen reported fish caught by the ika-shibi method. Of these, 175 reported 15 times or less in 1980 and are probably part-time fishermen, although a few may actually be supporting themselves mainly on fishing income. Fifty-eight of the 233 reported catches more than 15 times in 1980, with 103 as the highest number of reported catches. From personal observation and communications, it seems that the number of ika-shibi fishermen increased in early 1981, especially on Kauai, and that more than a few new boats were added to the fleet. It is likely that 300 or more fishermen will use the ika-shibi method at least once during 1981 and that the number of full-time

fishermen will increase by the end of the year.

The information in Table 3 shows the seasonality of various species in the fishery. Although the figures can be misleading because no effort data are available to compare with the catch data, the monthly catch figures indicate the effects of seasonal fishing effort and fish abundance on seasonality. The seasonality of the fishery also depends on the location, being slightly different for the east and west coasts of the islands. The east coast of the island of Hawaii generally has a fishing season lasting from May through October. The west coast seems to have a summer/early fall season also, but there seems to be a winter "run" of large tuna near the South Point area of Hawaii. In general, summer and early fall is the period of peak abundance of yellowfin tuna throughout the state. Yuen (1979) provides more details for the fishing season in Hilo.

DISCUSSION

As seen from the tables, the ika-shibi fishery has grown about six times larger since 1975 (see Table 4). This confirms the suspected rapid growth of the fishery within recent years. Although no data are available to confirm this, I don't think that the fishery has reached its maximum size yet.

The total ex-vessel revenues of the fishermen exceeded $2.9 million in 1980. Industry sources have cited estimates as high as $5 million as the total worth of the fishery. If the revenues of the wholesalers and retailers marketing the

ika-shibi catch are added to the fishermen's revenues, it seems that this estimate is accurate. This estimate will place the ika-shibi fishery as one of the more important fisheries in the state. Considering that individual fishermen have been estimated by fishery sources to have a gross income as high as $140,000 per year, with an estimated average gross income of $40,000 to $80,000 per year, it is not surprising that the fishery is experiencing rapid growth.

The ika-shibi fishery, along with the albacore troll fishery off the Northwestern Hawaiian Islands, is a very promising newcomer to the small but locally important fishing industry in the state of Hawaii. Since it is characteristically productive and low-cost, it is an ideal fishery development project for other small Pacific Ocean island groups. It has been found to be highly successful in the Philippines (Yuen, 1979). Attempts to introduce the ika-shibi method to other areas have met with varying degrees of success (Strong, 1979). If the ancillary fish-handling and transportation facilities are available, then it is potentially a highly profitable industry.

RECOMMENDATIONS

While the ika-shibi fishery possesses high growth potential, it is also hindered by certain problems. A condition known as "burnt tuna" occurs in a significant proportion of the ika-shibi catch. It appears as a pale, soft deterioration of raw tuna muscle which causes a sour, bitter taste and a

displeasing appearance to the raw tuna (Cramer, et. al., 1981). The incidence of burnt tuna is a serious problem, primarily because of the need for high quality in fresh tuna for the export market. Since the local market is too small to absorb the large quantities of fresh tuna caught during the peak season, export markets are important to the further expansion of the fishery (Hawaii Business, 1979). Burnt tuna occurs in tuna caught by other fishing methods, such as trolling and purse seining, but fish caught by these methods are not usually exported from Hawaii.

The first goal in improving the quality of fresh tuna should be the development of a burnt tuna assay for use on whole tuna. If the exporters can ensure that the tuna being exported are of high quality by assaying for burnt tuna, then export marketing losses will be eliminated. Secondly, the incidence of burnt tuna should be reduced by improvements in fishing and handling procedures so that a higher level of quality in fresh tuna can be maintained. Such measures will benefit both the local markets and the export markets.

As the ika-shibi fishery continues to grow, new fishing areas should be explored and exploited as the traditional fishing areas become more crowded. It is likely that not all islands will have suitable ika-shibi fishing areas, but I do not think that enough exploration has been done. Occasional anecdotal reports of ika-shibi fishing have been reported for areas of the state where ika-shibi fishing is not regularly

taking place. As a requisite for exploratory work, thorough studies should be made of the existing ika-shibi fishing grounds, such as food resources, oceanographic conditions, and fish migratory patterns in the area.

I also recommend that some mechanism be set up to collect data regularly from the ika-shibi fishery so that a good historical data base of the fishery can be established. Such a data base would be valuable in stock assessment studies, fishery management plans, research on topics such as burnt tuna, and in economic studies. Although the Hawaii Division of Aquatic Resources collects data on the deep-sea handline fishery, the catch data does not segregate bottom-fishing and ika-shibi catches. Furthermore, not all of the ika-shibi catch may be reported in the deep-sea handline data because it may be reported in other categories or not at all. The ika-shibi fishery is unique and deserves its own category.

The opinions and recommendations expressed in this report are my own and not of the National Marine Fisheries Service or the Hawaiian fishing industry.

ACKNOWLEDGEMENTS

I would like to thank the ika-shibi wholesalers and fishermen who very cooperatively furnished the data used in this report. I would also like to thank R. A. Skillman, J. C. Cooper, and H. S. H. Yuen for helpful criticism.

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TABLE 1

IKASHIBI FISHERY CATCH SUMMARY 1980

SPECIES	TOTAL WEIGHT(kg)	NUMBER	VALUE($)	SOURCES&
Yellowfin tuna	814,871#	21,110	2,618,945*	6
Albacore	43,645	1,837	71,374*	4
Bigeye tuna	29,266	819	108,611*	5
All tunas	887,782	23,756	2,798,930	-
Swordfish	19,720	269	58,507	3
Mahimahi	6,658	672	33,348	3
Marlin +	6,229	54	7,861	3
Striped marlin	2,570	73	7,070	2
Sailfish	111	9	359	1
Shortbill spearfish	30	1	86	1
Squid	2,437	-	4,268	2

Weight to nearest kilogram, converted from pounds.
Of this total yellowfin tuna catch, 5,825 kg of unidentified tuna were reported from Kauai. The remainder were reported from Hawaii.
* In some cases, a portion of the values are estimated.
+ Species not identified in records, probably blue marlin.
& Number of sources reporting catch.

TABLE 2

ESTIMATED NUMBER OF IKASHIBI FISHERMEN 1980

Number Reporting Catch (Of 233)		Mean no. reports	SD
1-5 Times per year	124	2.0	1.3
6-15 Times per year	51	9.8	2.6
>15 Times per year	58	40.2	24.0

Note: Data from 4 sources from the island of Hawaii. Mean number and standard deviation (SD) refer to the number of reports for each category at left.

TABLE 3

MONTHLY CATCH 1980

MONTH	YF	ALB	BE	MM	SW	BM	SM	SF	SQU
Jan	49,677	854	7,238	131	--	218	120	14	--
Feb	8,743	--	975	28	--	--	96	--	--
Mar	6,022	--	260	220	--	--	41	27	--
Apr	20,185	96	1,366	435	212	157	553	38	--
May	65,251	1,238	743	281	5,363	345	135	12	4
Jun	114,844	7,006	2,140	675	9,768	991	--	10	108
Jul	116,044	3,104	4,034	667	3,617	2,246	--	--	205
Aug	95,910	12,623	1,669	382	237	795	--	--	111
Sep	83,729	6,889	2,267	532	218	1,045	--	--	1,145
Oct	113,445	10,347	4,805	1,310	71	--	86	--	788
Nov	25,218	296	2,435	1,059	34	140	739	10	29
Dec	115,804	1,191	1,516	938	201	291	801	--	47

Catch listed to nearest kilogram.
Abbreviations in headings stand for: YF=yellowfin tuna, ALB=albacore, BE=bigeye tuna, MM=mahimahi, SW=swordfish, BM=blue or black marlin, SM=striped marlin, SF=sailfish, and SQU=squid.

TABLE 4

IKASHIBI CATCH DATA 1975

SPECIES	WEIGHT(kg)	VALUE($)
Yellowfin tuna	75,636	157,000
Bigeye tuna	63,182	149,500
Albacore	16,136	21,000
All tunas	154,955	327,500
Squid	1,273	3,500

Data from Yuen (1979), to nearest kilogram.

82-5

THE STATUS OF THE SQUID FISHERIES IN THE UNITED STATES OF AMERICA

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2570 Dole Street
Honolulu, Hawaii

WALTER M. MATSUMOTO

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March 1982

I. INTRODUCTION

The world's squid fisheries have risen to prominence shortly after the end of the Second World War, led by the rapid development of the fisheries by Japan. The Japanese production of squid reached a high of 758,500 tons in 1968 and has fluctuated between 400,000 and 600,000 tons annually (FAO 1954-80). The catch in 1979 was 512,000 tons. Other countries, notably Spain and Italy, began increasing their catches in the 1950's and with the entry of the Republic of Korea in 1953 and the U.S.S.R. in 1964 the world production of squid has increased from about 100,000 tons prior to the war to over 1 million tons in 1979.

A good portion of the increase in squid production has come from foreign vessels fishing off the Atlantic and Pacific coasts of the United States of America. Unfortunately, U.S.A. fishermen have not adequately participated in exploiting the squid resources within their own waters. Recently a great deal of interest has been generated in the U.S.A., particularly in the New England and Middle Atlantic States area, for the development of a domestic squid fishery. This report presents the status of the U.S.A. squid fisheries as they exist today.

II. SPECIES OF SQUIDS IN WATERS OF THE UNITED STATES OF AMERICA

A. Eastern United States of America and Gulf of Mexico

The waters off the eastern U.S.A. and the Gulf of Mexico are rich in species of cephalopods but only a few are either being harvested or considered of potential commercial value. These include:

Loligo pealei.—This is the "common" or long-finned squid of eastern North America. It occurs in most areas of the continental shelf from off New England through the Gulf of Mexico and has been reported from various scattered areas in the Caribbean. The young remain in coastal waters until fall (mid-November), with heavy aggregations appearing off the continental shelf during the cool season from November to March (Rathjen 1973). It attains a mantle length of about 20 cm (Okutani 1977), and is the object of international commercial fishing.

Loligo plei.—This is the arrow squid of tropical waters. It has a wide distribution in the western Atlantic from Cape Hatteras to Florida, the Gulf of Mexico, Caribbean Sea, and the northern coast of South America. It is a medium squid attaining a length of about 35 cm (Okutani 1977). It is slender and not as heavy as L. pealei. It occupies a mid-continental shelf range, generally from 20 to 75 m (Rathjen et al. 1979).

Lolliguncula brevis.—This is the "thumbstall" or brief squid of the Atlantic coast of the U.S.A. It occurs from Delaware southward through the Gulf of Mexico and along the coast of South America to the southern border of Brazil (Voss 1973). It is a short-bodied, heavy squid, very meaty and ideal for canning, with adults averaging 80 mm in mantle length in males and 100 mm in females. It was originally taken in some quantities in fish weirs along the Maryland-Virginia coast, but today almost the

entire catch is taken incidentally in shrimp trawls. It is associated with brackish or low-salinity waters and is found primarily in bays and nearshore waters to a depth of 20 m (Rathjen et al. 1979).

Illex illecebrosus.—This is the short-finned squid, or "common" squid of Newfoundland. It has been the object of a traditional fishery in waters adjacent to Newfoundland where jigging remains the basic approach to squid harvesting. The species, at least one of three species or subspecies present in waters of the Northwest Atlantic, ranges from Newfoundland southward along the eastern coast of the U.S.A. to Florida and the Gulf of Mexico, and along the coast of South America (Voss 1971, 1973). In Newfoundland it occurs in waters of about 15-25 m on the squid fishing grounds, but in the warmer waters of the the tropical western Atlantic it lives at depths of about 180-450 m. Although this squid has been valued primarily as bait, its food quality is excellent. Off Newfoundland this squid first appears in June at a length of about 16 cm. It grows rapidly and in October the males average 23 cm and the females are about 25 cm. In late October and November the larger animals, approaching sexual maturity, begin to disappear from inshore waters.

Ommastrephes pteropus.—This is the "orangeback" squid found over the outer part of the continental shelf and in the open sea south from Nova Scotia through the Caribbean and the Gulf of Mexico to Brazil and across the Atlantic. It is easily brought to a boat's side at night with lights and could easily support a large fishery. It is a moderate to large squid, very heavy and meaty, and the supply seems nearly inexhaustible (Voss 1971, 1973). Okutani (1977) gives a size of 35 cm and states that this squid is known from waters 22°-25° and is found at depths of 3,160 m to the surface.

Pholidoteuthis adami.—This species was first described by Voss in 1956. Voss examimed 31 specimens ranging in sizes from 14.6 to 30.5 cm. It is found in the upper Gulf of Mexico, east of the Mississippi Delta, and off the coast of Texas. Voss has reported that schools of this squid appeared on the surface several hours after sunset, and that on occasions a school would swim past the ship for several hours. This species could be present in sufficient numbers to support a commercial fishery.

B. Western United States of America and Alaska

Numerous species of squid are found in waters off the west coast of the U.S.A., but only one is the object of a fishery. Experimental fishing in the North Pacific by the Northwest Alaska Fisheries Center (NWAFC)[1] revealed a number of species which might be of commercial importance. These are as follows:

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[1]Mercer, R. W. (editor). 1981. Proceedings of the Squid Workshop. Sponsored by the Resource Assessment and Conservation Division, Northwest and Alaska Fisheries Center, 19-20 March 1981, Seattle, Washington. Northwest Alaska Fish. Cent. Processed Rep. 81-11, 34 p. Northwest Alaska Fish. Cent., Natl. Mar. Fish. Serv., NOAA, Seattle, WA 98112.

Loligo opalescens.—This species is presently taken commercially off California. It is a small squid with maximum mantle lengths of about 18 or 19 cm for females and males, respectively (Fields 1965). It is found from British Columbia to central Baja California. Adults congregate in vast numbers in shallow waters to spawn, primarily at depths of 15-35 m. Various estimates of the potential annual yield have been given, ranging from over 100,000 tons (Voss 1973) to 600,000 tons (Gulland 1970). The catch has averaged about 10,000 tons annually from 1970 through 1980.

Symplectoteuthis oualaniensis.—This is a medium-sized squid reaching 35 cm in length. It is an oceanic squid occurring throughout the tropical and subtropical waters of the Pacific and Indian Oceans. Off the west coast of the U.S.A. it occurs from off Oregon to Central America. This squid is plentiful and probably represents a very large potential. Voss (1973) speculates a potential of at least 100,000 tons in the central eastern Pacific. According to Voss, this squid is said to resemble the "surume-ika," Todarodes pacificus, of Japan and are often marketed as such there.

Dosidicus gigas.—This squid, often called the South American "giant" squid or Humboldt squid, ranges from California to Cape Horn with its major concentrations off Peru and the northern two-thirds of Chile. As an adult it attains a length of 2-3 m. In the younger stages (25-50 cm) they are often confused with S. oualaniensis of the same size (Voss 1973). A few tons have been landed in California from time to time but never in sufficient quantity to support a sustained fishery (Kato and Hardwick 1976).

Ommastrephes bartramii.—This is a medium-sized squid reaching 45 cm in length. It is an oceanic squid ranging from Alaska to Central America in the eastern Pacific, from north of the Aleutians to the Philippines in the western Pacific, and throughout the central Pacific north of the Equator (Okutani 1977). In 1978 this species comprised almost half of the squid catches taken in Japan's waters (Court 1980).

Onychoteuthis borealijaponicus.—This species reaches about 29 cm in length. It is an oceanic squid distributed continuously across the northern half of the North Pacific, northward from Taiwan in the west, and Baja California in the east. It is of occasional commercial importance in the Japanese squid fishery.

Berryteuthis magister.—This is a small, soft-bodied squid of about 22 cm. It is found off Japan, the Aleutian Islands, and along the coasts of Alaska, Canada, and Northwestern U.S.A. and has been taken at depths of 300 m. It has been taken in trawls and is fed upon by whales (Okutani 1977).

Other squid of the Family Gonatidae (which includes B. magister) that occur in the Bering Sea, along the Aleutian Islands, the coasts of Alaska, Canada, and northwestern U.S.A. and which are of potential

commercial importance are Gonatopsis borealis, Gonatus onyx, and G. fabricii (Laevastu and Fiscus 1978).[2]

III. STATUS OF THE UNITED STATES OF AMERICA SQUID FISHERIES

A. Northeastern Fishery

The U.S.A. fishermen have been landing squid in the northeastern coast since the 1880's but have never been aggressive in fishing for them. The catches have ranged from 0.9 to 6,000 tons between 1953 and 1979 (Table 1). Most of the squid have been taken incidental to fishing for other fish species in inshore grounds and the American fishermen have yet to fully exploit the offshore stocks. Perhaps the main cause of the low U.S.A. catches have been the lack of a substantial domestic market.

On the contrary, squid has long been a popular food fish in certain foreign markets and thus a highly sought marine resource by foreign fishing fleet. Foreign vessels began reporting incidental catches of squid off the northeastern coast in 1964, with directed fishing starting in 1968 (Lange and Sissenwine 1980). The combined foreign and U.S.A. catch rose rapidly in the next 5 years, reaching a peak of 56,768 tons in 1973 (Table 2). From 1972 to 1976 the combined fleet has taken an average of 52,500 tons per year, of which 45,600 tons were taken by foreign vessels. Since 1977, however, the annual catches by foreign vessels have declined somewhat to about 28,500 tons in 1978.

The U.S.A. landings in the northeastern fishery have remained relatively steady at 1,000-2,000 tons between 1963 and 1978, with the exception in 1976, when the catch exceeded 3,800 tons (Table 2). The fishery, which includes the New England, mid-Atlantic, and Chesapeake regions, catches well over 90% of all squids taken by the U.S.A. in the Atlantic Ocean and the Gulf of Mexico (Table 3).

Landings are composed mostly of Loligo pealei which make up 71% of the total catch. Illex illecebrosus, the principal species taken off Newfoundland where catches of nearly 100,000 tons have been reported in 1978 (Hurley 1980), is also found along the coasts of Maine and Massachusetts. The U.S.A. fishery for Illex is well below that for Loligo, although it equaled that of the latter species in 1977 (Table 4).

B. South Atlantic and Gulf of Mexico Fisheries

Only a small part of the U.S.A. squid catch comes from the southeastern region of the U.S.A. and the Gulf of Mexico (Table 3), where L. pealei and L. plei make up the bulk of the catch. Another species, Lolliguncula brevis, also enters into the catch. According to Voss (1973) L. brevis was originally taken in some quantities in fish weirs along the

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[2]Laevastu, T., and C. Fiscus. 1978. Review of cephalopod resources in the eastern North Pacific. Northwest Alaska Fish. Cent. Processed Rep., 15 p. Northwest and Alaska Fish. Cent., Natl. Mar. Fish. Serv., NOAA, Seattle, WA 98112.

Table 1.--U.S. squid landings (thousand metric tons).[1]

Year	Atlantic	Pacific	Total
1950	1.1	2.1	3.2
1951	2.5	5.6	8.1
1952	0.9	1.7	2.6
1953	2.6	4.0	6.6
1954	1.6	3.7	5.3
1955	1.9	6.5	8.4
1956	1.4	8.8	10.2
1957	2.7	5.6	8.3
1958	2.0	3.4	5.4
1959	1.7	8.9	10.6
1960	1.6	1.2	2.8
1961	1.5	4.7	6.2
1962	2.2	4.3	6.5
1963	2.2	5.2	7.4
1964	1.0	7.4	8.4
1965	1.2	8.4	9.6
1966	1.2	8.6	9.8
1967	1.8	9.0	10.8
1968	1.7	11.5	13.2
1969	1.7	9.4	10.1
1970	1.0	11.2	11.2
1971	1.2	15.8	17.0
1972	1.3	9.1	10.4
1973	1.8	5.5	7.3
1974	2.4	10.6	13.0
1975	1.6	7.8	9.4
1976	3.8	9.2	13.0
1977	2.4	8.8	11.2
1978	1.6	17.0	18.6
1979	6.0	16.0	22.0

[1]As reported in FAO. Yearbook of fishery statistics, catches and landings (1954-80).

Table 2.--Annual squid catches[1] (*L. pealei* and *I. illecebrosus*) in metric tons, 1963-78, by country, from the Northwest Atlantic, Cape Hatteras, North Carolina, to the Gulf of Maine (from Lange and Sissenwine 1980).

Year	Country[2]															
	Bulg.	Can.	Cuba	Fra	FRG	GDR	Ire.	Italy	Japan	Pol.	Rom.	Spain	U.S.A.	U.S.S.R.	Mex.[3]	Total
1963													2,104			2,104
1964													934	4		938
1965													1,153	177		1,330
1966																
1967									7				1,174	344		1,518
1968			10						1,734				1,251	1,411		2,669
1969			1						7,711				1,762	3,176		6,682
1970						20			13,639			566	1,461	1,340		11,079
1971	90	1							10,602			4,426	1,061	1,065		20,211
1972	499		14	296	463			3,200	18,691	5,428	66	6,770	1,182	6,138		24,783
1973	410			820	1,641	313		3,165	15,526	9,199	150	10,545	1,197	6,976		47,375
1974	592	27						4,260	16,820	6,709	9	14,932	1,635	8,977		56,768
1975	205		151		27	898	4,745	4,274	13,985	6,836	48	16,144	2,422	8,495		55,478
1976	23	54	265		1,023	1,313	3,283	4,421	8,285	6,756	22	9,902	1,728	8,928		51,727
1977	60	20	34			9	23	4,185	12,690	888		13,200	3,831	7,644		50,120
1978								3,497	6,053		67	13,438	2,112	8,010		41,469
												13,186	1,861	40	3,822	28,526

[1]1963-76—ICNAF (International Commission of the Northwest Atlantic Fisheries) Statistical Bulletins No. 13-26; 1977--ICNAF Summary Document No. 78/VI/28. Provisional Nominal Catches in the Northwest Atlantic, 1977; 1978--Preliminary, as reported to NMFS by foreign fisheries officials.

[2]Countries are: Bulgaria, Canada, Cuba, France, Federal Republic of Germany, German Democratic Republic, Ireland, Italy, Japan, Poland, Romania, Spain, United States of America, Union of Soviet Socialist Republics, and Mexico.

[3]Mexico did not fish in this area prior to U.S.A. extended jurisdiction.

Table 3.--Squid landings (in metric tons) by region, U.S. east coast and Gulf of Mexico.[1]

Year	New England	Mid-Atlantic	Cheasapeake	South Atlantic	Gulf of Mexico	Total
1960	948	549	137	7	14	1,655
1961	554	801	158	14	14	1,541
1962	1,124	907	116	12	27	2,186
1963	1,217	757	132	14	33	2,153
1964	252	628	61	20	21	982
1965	381	647	116	16	24	1,184
1966	237	752	193	16	28	1,226
1967	825	632	265	19	22	1,763
1968	836	626	202	21	40	1,725
1969	875	411	176	13	26	1,501
1970	497	343	196	12	25	1,073
1971	802	234	191	9	23	1,259
1972	656	533	121	10	10	1,330
1973	1,164	509	79	20	21	1,793
1974	1,289	1,021	106	47	30	2,493
1975	1,196	685	64	42	20	2,007
1976	2,833	900	69	24	33	3,859

[1]As reported in U.S. National Marine Fisheries Service. Fishery statistics of the United States (1962-80).

Table 4.--Squid catches (in tons), by species,[1] year, and country, from the Northwest Atlantic, Cape Hatteras to the Gulf of Maine, 1963-78 (from Lange and Sissenwine 1980).

Year	Country[2]															Total
	Bulg.	Can.	Cuba	Fra.	FRG	GDR	Ire.	Italy	Japan	Pol.	Rom.	Spain	U.S.A.	U.S.S.R.	Mex.[3]	
									Long-finned squid							
1963													1,294			1,294
1964													576	2		578
1965													709	99		808
1966													722	226		948
1967									5				547	1,125		1,677
1968									177				1,084	2,150		3,411
1969									7,125			438	899	1,080		9,542
1970									13,250			2,790	653	692		17,385
1971	10								10,426			3,446	727	3,560		18,169
1972	20			288	463			2,000	16,293	164	66	5,667	725	4,048		29,734
1973	46			793	1,641			2,360	14,459	911	150	11,148	1,105	5,000		37,613
1974	172	27						3,280	13,493	1,706	3	9,375	2,274	4,520		34,850
1975	34		30		27	16	1,660	3,390	10,748	3,785		7,698	1,621	4,792		33,801
1976	23		257		22	317	1,042	3,304	5,029	1,706	13	9,137	3,602	832		25,284
1977	8	15	28			9		2,237	7,814	232		5,236	1,088	7		16,674
1978								1,366	2,309		17	4,603	1,476	7	1,053	10,831

Table 4.--Continued.

Year	Country[2]														
	Bulg.	Can.	Cuba	Fra.	FRG	GDR	Ire.	Italy	Japan	Pol.	Rom.	Spain	U.S.A.	U.S.S.R.	Mex.[3]	Total
								Short-finned squid								
1963													810			810
1964													358	2		360
1965													444	78		522
1966													452	118		570
1967									2				707	286		995
1968			10						1,557				678	1,026		3,271
1969			1						586			128	562	260		1,537
1970						20			389			1,636	408	373		2,826
1971	80	1							176			3,325	455	2,578		6,614
1972	479		14	8				1,200	2,398	5,264		4,878	472	2,928		17,641
1973	364			27		313		805	1,067	8,288		3,784	530	3,977		19,155
1974	420							980	3,327	5,003	6	6,769	148	3,975		20,628
1975	171		121			882	3,085	884	3,237	3,051	48	2,204	107	4,136		17,926
1976		54	8		1,101	996	2,241	1,117	3,256	5,050	9	4,063	229	6,812		24,936
1977	52	5	6				23	1,948	4,876	656		8,202	1,024	8,003		24,795
1978								2,131	3,744		50	8,583	385	33	2,769	17,695

[1]1963-66--estimated breakdown of total squid catch, prorated by ratio of reported L. pealei to I. illecebrosus, from ICNAF Statistical Bulletins No. 13-16; 1967-76--ICNAF Summary Document No. 78/VI/6; 1977--ICNAF Summary Document No. 78/VI/28; 1978--Preliminary, as reported to NMFS by foreign nations.

[2]Countries are: Bulgaria, Canada, Cuba, France, Federal Republic of Germany, German Democratic Republic, Ireland, Italy, Japan, Poland, Romania, Spain, United States of America, Union of Soviet Socialist Republics, and Mexico.

[3]Mexico did not fish in this area prior to U.S.A. extended jurisdiction.

Maryland-Virginia coast. More recently, however, almost the entire catch has been taken incidentally in shrimp trawls. Areas of prevalence were reported as Georgia-north Florida, west Florida, and the upper Gulf of Mexico. There are no estimates of catch or availability for this species as most landings are grouped under "squid" and are not separated by species. Rathjen et al. (1979) report that most squid landings in the northwestern gulf consist of incidental catches of "white" squid, L. brevis, in the bay and nearshore trawl fishery for white shrimp, and that few "red" squid, Loligo plei and L. pealei, are caught by the offshore brown shrimp fishery.

C. West Coast Fishery

Practically the total squid production of the U.S.A. west coast, including Alaska, comes from the California fishery for the common market squid, Loligo opalescens. A few tons of the jumbo squid, Dosidicus gigas, have been landed from time to time but never in sufficient quantity to support a sustained fishery. Most other species are either too small or not readily available to the fisheries (Kato and Hardwick 1976). The landings of squid in the Pacific have fluctuated from 1,200 to 9,000 tons in the 1950-67 period, but have averaged 11,000 tons over the last 12 years, 1968-79 (Table 1). While the landings were significantly higher than in the eastern U.S.A., they were insignificant when compared with the world squid landings, which averaged well over 820,000 tons over the 1968-79 period (FAO 1954-80).

The California squid fishery is essentially two fisheries, one centered at Monterey and the other in southern California at the Channel Islands, seaward from the Los Angeles area (Kato and Hardwick 1976). The landings at Monterey have generally remained between 3,000 and 6,000 tons annually from 1963 through 1974, with a high of over 9,000 tons in 1971 and a low of 563 tons in 1973 (Table 5). In 1975 and 1976 the landings were slightly above 2,000 tons, well below the average. Some constraints were placed on the Monterey fishery by the State of California when it outlawed the use of purse seines in Monterey Bay in 1953 to prevent the net from uprooting and damaging the sessile spawned squid eggs. Spawning occurs there in shallow waters and the lead line of the seines often reached the bottom during sets. Another law introduced in 1959, which limited fishing activity in the bay, banned the use of lights to attract squids. This effectively excluded the use of brailing and pumping methods of capturing squids (Kato and Hardwick 1976). In the southern California fishery the landings have increased from a low of 148 tons in 1960 to 7,200 tons in 1970, and have fluctuated between 3,000 and 8,500 tons from 1971 to 1976. Thus, except for the years 1973, 1975, and 1976, the Monterey and southern California fisheries have remained about equally productive, despite the restrictions placed on the use of purse seines and squid attraction lights in Monterey Bay.

IV. FISHING METHODS AND GEAR

Squids are taken in U.S.A. waters by a variety of methods and gear, including purse seine, lampara nets, otter trawls, pound nets, floating

Table 5.--Squid landings (in metric tons) in the California fishery.[1]

Year	Monterey	Southern California	Total
1960	1,014	147	1,162
1961	1,672	2,994	4,666
1962	2,564	1,685	4,249
1963	3,064	2,180	5,244
1964	4,128	3,326	7,454
1965	4,021	4,425	8,446
1966	5,084	3,546	8,630
1967	5,095	3,796	8,891
1968	6,613	4,697	11,310
1969	5,344	4,182	9,426
1970	3,913	7,241	11,154
1971	9,248	6,745	15,993
1972	5,560	3,584	9,144
1973	563	4,938	5,501
1974	6,575	6,536	13,111
1975	2,263	8,469	10,732
1976	2,278	6,947	9,225

[1]As reported in U.S. National Marine Fisheries Service. Fishery statistics of the United States (1962-80).

traps, handlines, gill and trammel nets, and dip, brail, or scoop nets. The varieties of gear employed differ somewhat from region to region.

In the northeastern fishery, the bulk of the annual catch (about 85%) is made in otter trawls as incidental catches in the bottom fish fishery, about 10% in pound nets, and roughly 5% in floating traps. In some years the otter trawl catch comprises 95% of the total catch, while in others the pound net catch exceeds 18%. In addition to these, purse seines, handlines, and midwater trawls are used in some years; however, the catches from these gear are insignificant, well below 1%. A breakdown of the catch in 1976 shows that 0.3 ton of squid were taken in purse seines, 3,858 tons in bottom fish trawls, 382 tons in pound nets, 252 tons in floating traps, and 4.5 tons in midwater trawls (U.S. National Marine Fisheries Service (NMFS) 1980).

Other means of catching squids have been tried in the area in recent years. In 1973-75 the Japanese conducted exploratory fishing between Cape Hatteras and the Grand Banks by sending a vessel equipped with squid jigging machines. Fishing south of Georges Bank along the edge of the continental shelf yielded 103 tons of Illex illecebrosus in 112 days of fishing in 1973 and 1974 (Ichikawa and Sato 1976). In 1979 two Polish vessels also equipped with squid jigging machines conducted exploratory fishing southeast of Cape Cod (Long and Rathjen 1980). One vessel caught 32 tons of Illex in 15 days of fishing, an average of 2.1 tons per day, and the other caught 31.3 tons in 11 days, an average of 2.8 tons per day.

In the southeastern and gulf fisheries, nearly all of the squids are taken as incidental catches in shrimp trawls.

In the west coast southern California fishery the bulk of the squid catch is made with purse seines and power-assisted brail, used in conjunction with squid-attracting lights (Kato and Hardwick 1976). No special seines are used for squids, but the anchovy and mackerel seines are employed whenever the opportunity arises. In most years 80-95% of the catch is made with purse seines but in some years the catch with brail, scoop, or dip nets comprise 56-66% of the total annual catch (NMFS 1980).

Kato (1970) developed a unique method of catching squid with a hydraulic centrifugal pump. While only one fisherman has used the pump successfully, the method appeared promising. During the 1973-74 season the vessel, using the fish pump as well as the brailing method, caught 710 tons of squid in 43 delivery days for an average of 16.7 tons per day (Kato and Hardwick 1976). The range in catch per night varied from under a ton to 54 tons. The authors also reported that catches of 75-85 tons had been made with the pump in 1 night's fishing by this same vessel in prior years.

The catch in Monterey is made almost entirely with lampara nets. Occasionally squids are caught in traps and on lines but the catches comprise less than 0.5% of the total annual landings. Scoop or dip nets are used frequently with catches comprising less than 3% of the total catch. In most years the catch by scoop or dip nets does not exceed 1% of the total catch (NMFS 1980).

V. UTILIZATION OF CATCH

Until 1973 about 75% of the catch in the northeastern and mid-Atlantic fisheries was sold to the fresh market or used as bait, but since then more of the catch has been frozen and exported to European countries. Some of the catch has been canned since 1958 with the operation of a cannery in New York in 1958 and another in New Jersey in 1959 (Power 1960, 1961). The only commercially prepared squid product produced in the U.S.A. is squid canned with or without its ink in brine, in oil, and in tomato sauce (Ampola 1974).

In California the squid catch is canned or frozen and exported to European markets, Latin American countries, and to the Orient, particularly the Philippines. Domestic consumption is mostly in frozen form, and a considerable amount of frozen squid is also used as bait in both commercial and recreational fisheries. Squid taken by commercial vessels are usually sold to freezer plants first because of the higher price, and the canners receive the excess beyond the processing capacity of the freezer plants. Thus, in times of high availability, more squid is canned (Kato and Hardwick 1976). Squid has been canned in California for many years. In 1948, 20 canning plants produced 349,800 cases from 7,632 tons of squid. The number of canneries fluctuated greatly but has remained at about 6 in recent years.

In 1976, the latest year for which published data are available (NMFS 1980), the U.S.A. canned 3,302 tons of squid, producing 151,333 cases valued at $1,725,000, with eight canneries in operation, two on the east coast and six in California. A total of 2,784 tons of squid were frozen, with the breakdown by regions as follows: Northeast - 1,361 tons; mid-Atlantic - 96 tons; south Atlantic - 81 tons; and California - 1,245 tons. Fresh and frozen squid used for industrial products included 158 tons for animal food and 1,495 tons for bait.

American consumer demand for squid traditionally has been low, with domestic consumption limited primarily to sales of fresh and frozen squid to ethnic groups in certain metropolitan areas. Recently squid has gained some popularity as an entreé in California restaurants (Ampola 1974) and a study designed to assess market potential in New England has been started (Rathjen 1977), but neither development has yet had a large impact on consumer patterns. Possible opportunities may exist for specialty convenience-type packs to be offered to the mass consumer or the "fast-food" market area, and in domestic use in seafood chowders or as a partial replacement for certain other shellfish, i.e., clams in chowders, soups or other preparations (Rathjen et al. 1977).

Hixon et al. (1980) suggest two domestic marketing approaches to be considered at this time. "One is through the larger-scale consumer and restaurant trade route, and the other is to introduce the product on a small scale as specialty items in local seafood or ethnic restaurants. The first approach requires relatively complex and extensive channels of distribution that must first be developed to insure wide market acceptance. To overcome consumer unfamiliarity with squid and gain mass market

acceptance, a well-coordinated promotion program by large seafood processors or a restaurant chain must be instituted.

"The second marketing approach seems more appropriate at this time. Small-scale introduction seems best done initially by small processors who could introduce processed squid specialty items such as stuffed squid or breaded squid rings and strips to local small markets, including certain urban ethnic populations which are familiar with squid, and coastal areas or seafood restaurants where one might expect to find squid as a menu item. Once squid has gained public awareness and acceptance on this small scale, steps may be taken toward the development of mass market acceptance."

VI. DATA COLLECTED

Data on squid may be found in several publications: FAO Yearbook of Fishery Statistics, Fishery Statistics of the United States, ICNAF Statistical Bulletin, California Marine Fish Landings, and Fish Landings Statistics of Other Coastal States. The first four sources provide coverage of the areas where squid are presently taken. The FAO Yearbook and the ICNAF Bulletin list the squid by individual species. However, because not all countries report catch by species, a category of a larger taxonomic group is also included. A description of each publication and the types of data presented are summarized below.

FAO Yearbook of Fishery Statistics.—Squid landings or catches are reported by species, major fishing areas, and country. The major squid species are indicated but because not all countries report catch by species a category of combined families is included. The listing by species first appeared in the statistics for 1971. The data are published annually with a time lag of 1 year.

Fishery Statistics of the United States.—Squid data are reported in various forms: Landings of species by region with corresponding dollar values; landings of species by state and region; landings of species by gear, state and region; landings of species by distance caught off U.S. shores and in international waters; and landings used for industrial products by region. Also reported are summaries of quantity and value of processed fishery products (canned), freezing by month and region, and U.S. exports of domestic products. Species breakdown apply largely to fish and crustaceans and are given in common names. Squid are all grouped under one heading - squid. The data are published annually with a time lag of 4 years.

ICNAF Statistical Bulletin.—The Bulletin, which is issued annually by the International Commission for the Northwest Atlantic Fisheries, is based on statistics of fishing effort and nominal catches for the Northwest Atlantic (FAO Major Fishing Area 21), as reported by member countries of the Commission. Data for nonmember countries are included as they become available. Statistical reports were received from 20 countries for the year 1978. Squid catches are presented in various ways: (1) by species and subarea (see Fig. 1 for subdivisions of area); (2) by species groups by division and country; (3) by individual species by division and country;

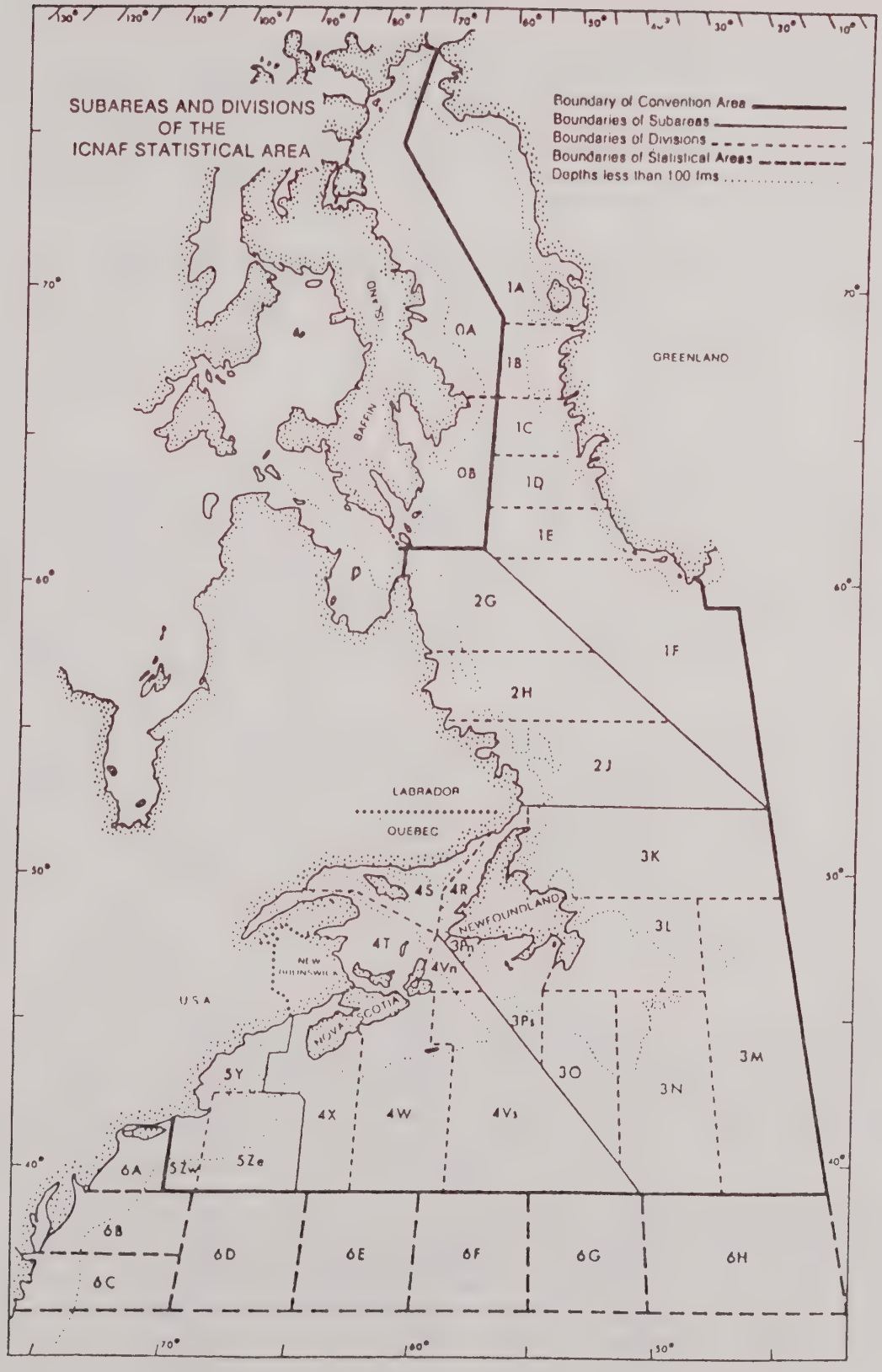

Figure 1.--Subareas and divisions of the ICNAF statistical area.

(4) by selected species by division, country, and month; (5) fishing effort and catches by division, month, gear, main species, vessel tonnage class, and country; (6) summary of catches and fishing effort for each country by gear, vessel tonnage class, and subarea; and (7) catch and effort statistics for countries whose vessels fished in the Northwest Atlantic under cooperative arrangements with Canada. Time lag for the published report is 2 years.

California Marine Fish Landings.—Squid catches are reported as (1) annual landings from California waters, (2) monthly landings of commercial boats by area, (3) value of landings and shipments into California by area, (4) weight and value of landings by port and area, and (5) catch of live bait for sport fishing. Statistics are published annually with a time lag of 2-3 years since 1971. Squid are listed as "squid, common market" (= L. opalescens).

Much of the recent studies on squids off the Northeastern United States of America and Canada have come from the ICNAF area, nearly all concerning the two species (L. pealei and I. illecebrosus) taken in large quantities commercially. These studies include such areas as abundance, age and growth, growth and life cycle, distribution and biological characteristics, length-weight relationships, maturation and fecundity, biomass estimates based on catch and catch rates, stock assessment based on commercial trawl catches, and biological considerations relevant to the management of the fishery based on data collected from commercial and research vessels.

In the Southeastern U.S.A. species composition, distribution and abundance of squids common to the area are being investigated from data collected from Marine Resources Monitoring, Assessment, and Prediction (MARMAP) trawl surveys (Whitaker 1980). In the northeastern Pacific species composition and other biological information on squid are being obtained from samples and data collected from stomachs of seabirds and the northern fur seal and from the Northwest and Alaska Fisheries Center's high seas drift gill net sampling program.

VII. ASSESSMENT OF RESOURCE

Voss (1973) stated that probably less than 10% of the world's ocean surface is at present being fished for cephalopods, i.e., that part of the ocean from the middle of the continental slope to the shoreline, and that probably 99% of all of our present catch is taken from this area. Thus about 90% of the ocean's area is unexploited. Yet this is the home of very large numbers of species of cephalopods that seldom stray inshore but spend their entire life cycle in the high seas.

Attempts to assess the potential productivity of squid in the oceanic area have largely been done on the basis of the amount of squid consumed by the sperm whale. Boerema (1970:cited by Voss 1973, but not included in his list of "References") has considered that the estimated 50,000 sperm whales off Peru consume about 1.46 million tons of squid annually (about 30 tons annual consumption per whale). Clarke (1977), by taking 1.2 million as the

total population of sperm whales, using 15 tons and 5 tons as the mean weights of males and females, respectively, and estimating the food consumption of 2% of body weight per day by males and 3% by females, derived a "conservative" estimate of at least 100 million tons of squid eaten in 1972. Further, by accepting a value of 15 tons for the average whale and a consumption of 3.5% of body weights per day, as well as an average calorific value of 75% of that for muscular squids, he estimated the amount eaten as 320 million tons. Based on Boerema's and other estimates gathered from various sources, including those by Clarke through personal communication, Voss (1973) gave the potential estimates of squid from the continental shelf fisheries in the Northwest Atlantic as 500,000 tons, and in the Northeast Pacific (waters off North America) as 600,000 tons.

Laevastu and Fiscus (see footnote 2) attempted a conservative estimate of squid consumed in the North Pacific with the following numbers: number of sperm whales - 150,000; average weight - 15 tons; average food requirement - 4% of body weight daily, of which 90% are squid. Thus, they estimated that the North Pacific sperm whales would consume about 30 million tons of squid annually. Further, nearly all pelagic marine mammals, including other whales, feed to some extent on squid, and smaller squid are eaten by all larger pelagic fishes and some species of marine birds. Thus, the marine ecosystem in the North Pacific was estimated to consume about 200 million tons of squid annually as food.

At the present state of knowledge of the squid fisheries, with usable data lacking on egg production and distribution, growth, longevity, stock sizes of most species and incomplete reporting of catch and effort data from many regions, it is difficult to give any reality to the potential estimates given above. The potential, nevertheless, appears quite promising.

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APPROACHES TO RESOURCE ASSESSMENT FOR LOBSTER, BOTTOM FISH, MONK SEAL, AND GREEN TURTLE STOCKS IN THE NORTHWESTERN HAWAIIAN ISLANDS

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I. INTRODUCTION

The Honolulu Laboratory, Southwest Fisheries Center, National Marine Fisheries Service (NMFS) is assessing the stocks of spiny lobster, Panulirus marginatus, a snapper (Lutjanidae) and grouper (Serranidae) complex of bottom fishes, the Hawaiian monk seal, Monachus schauinslandi, and the green turtle, Chelonia mydas, in the Northwestern Hawaiian Islands (NWHI).

The NWHI is an area of reefs, banks, and islands located northwest of Honolulu stretching from Nihoa Island 1,250 nmi northwest to Kure Atoll. The spiny lobster and bottom fish resources support a modest fishery in the NWHI. The monk seal is an "endangered" species breeding only in the NWHI and the green turtle is considered a "threatened" species under the U.S. Endangered Species Act.

A. Spiny Lobster

The spiny lobster fishery began in 1975 when the NOAA ship Townsend Cromwell, a research ship assigned to the Honolulu Laboratory, documented good catch rates of spiny lobster, at the lower end of the chain. In 1975 the commercial catch was 2,000 kg. Each subsequent year the catch has increased and the current catch for 1981 is estimated at 300,000 kg (Skillman and Ito[1]). The rapid development of this fishery has raised concern that overfishing may occur and work to develop a fishery management plan (FMP) was initiated by the Western Pacific Regional Fishery Management Council (WPRFMC). The Honolulu Laboratory has contributed to this FMP by undertaking work to: 1) Determine the distribution of the resource throughout the NWHI chain, and 2) estimate the sustainable yield of the resource. The data available for these analyses consist of sampling data collected on research cruises of the Townsend Cromwell, and some commercial catch and effort data.

The data collected by the Townsend Cromwell represent a systematic sampling survey with catch and effort data collected from 0.1° squares around the banks and islands of the NWHI. This catch-per-unit-effort (CPUE) data were used to prepare charts of the relative abundance of the spiny lobster stock throughout the NWHI (Uchida et al. 1980).

The estimation of sustainable yield for the region was based on the commercial catch and effort data base. There currently is no regulation that requires commercial vessels to report their catch and effort and, hence, only an intermittent catch and effort data series submitted on a voluntary basis was available. While the catch and effort time series were too short and sporadic for surplus production analysis, a series of catch and effort data which represented intensive trapping applied to a previously unexploited population was available for analysis. Based on this intensive catch and effort data, an estimate of preexploitation population size (N_0) and catchability (q) could be obtained by computing a regression of CPUE on cumulative catch (Leslie method, Ricker 1975, p. 150).

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[1] Skillman, R. A., and B. M. Ito. 1981. The present status of the spiny lobster fishery in Hawaiian waters. Southwest Fish. Cent., Honolulu Lab., Natl. Mar. Fish. Serv., NOAA, Admin. Rep. H-81-7, 4 p.

Another approach to estimate preexploitation biomass was applied to data collected from Necker Island at the lower end of the chain where much of the earlier commercial effort was directed. This approach was based on a method proposed by Allen (1966) in which population size and catchability are estimated in a manner which minimizes the sum of squares between the actual catch and the predicted catch, given effort. In its most general form, this model assumes that the rate of natural mortality is constant while recruitment may vary over time. This most general form requires that the user supplies estimates of the natural mortality and recruitment rates. We did not have any estimate of recruitment rate and hence modified Allen's model. We assumed that the ratio of the rate of natural mortality to the recruitment rate was constant over the 2-year period for which data were available. This ratio together with population size and catchability are then estimated by least squares. Application of this method to 24 months of commercial catch and effort data from Necker Island produced estimates of catchability and population size which were in agreement with the estimates obtained from the same site by an intensive fishing analysis (Polovina and Tagami 1980).

Once preexploitation population size, and hence biomass, were obtained for several areas where research sampling CPUE data were available, a linear regression of biomass per unit area on research sampling CPUE was used to obtain on estimate of total biomass for the entire NWHI. Based on this total estimate of preexploitation biomass (B_o), rough approximations of lobster maximum sustainable yield (MSY) for the NWHI were obtained based on Gulland's (1971) relationship:

$$MSY = M\ B_o/2$$

where M = annual instantaneous natural mortality,

and a method proposed by Pauly (1981[2]):

$$MSY = 2.3\ \bar{w}^{-0.26}\ B_o$$

where $\bar{w}$ is defined as the average of the weight at first maturity and the maximum weight of the lobster in the population (in grams).

To estimate natural mortality (M) for Gulland's relationship, the following relationship (Beverton and Holt 1956) was used on data obtained at sites with little or no fishing:

$$F+M = K(L_\infty - \bar{L})/(\bar{L} - L_{min})$$

where $\bar{L}$ is the mean carapace length from the trappable population, L_{min} is the minimum carapace length from the trappable population, and K and L_∞ are the parameters from the von Bertlanffy growth equation which were estimated from modal analysis of length-frequency data.

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[2]Pauly, D. 1981. Studying single-species dynamics in a tropical multispecies context. Prepared for ICLARM/CSIRO Workshop on the Theory and Management of Tropical Multispecies Stocks, 12-23 January 1981, Cronulla, Australia. International Center for Living Aquatic Resources Management, MCC P. O. Box 1501, Makati, Metro Manila, Philippines, 65 p.

While these methods produced estimates which can only represent rough approximations, it appears that the results nonetheless represent reasonable first approximations. The approach described produced estimates of annual MSY ranging from 100,000 to 200,000 kg (WPRFMC[3]). The yield for 1981 was 300,000 kg; however, the substantial decline in catch rate and lobster size suggests that this yield is not sustainable. Once the FMP is in force and commercial catch and effort data can be collected, it is anticipated that these estimates will be revised.

Two difficulties encountered in this analysis were the availability of only short and sporadic commercial catch and effort data and the difficulty of obtaining precise estimates of growth parameters. Both tagging data and analysis of modes and modal progressions of length-frequency data were used to estimate growth parameters. The tagging approach suffered from insufficient recoveries and relatively slow apparent growth for the animals recovered possibly due to an effect of tagging on growth. The analysis of length-frequency data showed large variances in growth due to the difficulty in identifying modes which was apparently caused by the large variance in size among lobsters of the same cohort.

B. Bottom Fishes

The bottom fish fishery exploits a complex of species, especially snappers (Pristipomoides spp., Etelis spp., and Aprion virescens), but including also jacks (Carangidae: Caranx spp., Carangoides spp., and Seriola dumerili) and a grouper (Epinephelus quernus). The fishery is conducted in deep (60-340 m) offshore waters using baited hook-and-line gear, and powered mechanical line-haulers.

Bottom fishes have been exploited around both the main Hawaiian Islands and the NWHI since at least 1945. However, until recently only one vessel regularly fished in the NWHI. Recently more commercial vessels have begun exploiting bottom fish stocks in the NWHI but the data base of commercial catch and effort for the NWHI is not sufficient to perform a stock-production analysis. A larger data base for commercial catch and effort data around the main Hawaiian Islands is available and a stock-production analysis of the bottom fish resource around the main islands of the State was completed using a 20-year series of catch data collected by the Hawaii Division of Aquatic Resources (Ralston and Polovina in press). Although fishing effort statistics were not specifically maintained, a computer program sorted through the data base and tallied the number of fisherman-days expended each year in the fishery. The stock was treated as a multispecies fishery and analyzed by application of the Total Biomass Schaefer Model (TBSM) (Pope 1979). Cluster analysis of the data showed that bottom fish species could conveniently be divided into three somewhat distinct groups which appeared to be segregated on the basis of depth and could be analyzed by the use of TBSM. Using aggregation theory it was demonstrated that the cluster groups provided a more accurate and biologically meaningful way of expressing production in a multispecies framework. The analysis also showed that the fishery is currently close to MSY.

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[3]Western Pacific Regional Fishery Management Council. 1981. Draft fishery management plan, May 1981, 208 p.

The chief liability of this study was that the measure of fishing effort which was employed had to be determined after the fact. Interpretation of the statistic used became most difficult as a result. Furthermore, the recreational catch of bottom fish in Hawaii is unreported and thus unaccounted for. Consequently, estimates of surplus production from this analysis can only be considered as a lower bound for yield potential.

A yield-per-recruit analysis of Pristipomoides filamentosus has also been completed. This is the most important species in the fishery and it was studied in some depth to complement the results of the stock-production study. In an investigation of the growth dynamics of this species, the density of daily increments in sagittal otoliths was integrated to estimate age (Ralston and Miyamoto in press). The daily periodicity of the increments was validated by in vivo tetracycline labeling of otoliths and examination of shifts in field sampled size-frequency distribution. An age-length key was generated from regression statistics derived from the estimated age-length data. This key was then applied to length-frequency samples to estimate mortality rate using the catch curve method. Experimental fishing trials were conducted to assess the likelihood of severe size bias in these hook-and-line samples. The yield-per-recruit calculations for P. filamentosus showed that eumetric conditions currently prevail for this species at a relatively high level of yield (Ralston 1981). This result is considered compatible with the finding that the fishery is now operating close to its MSY.

A major difficulty in these studies was the labor-intensive nature of working with daily increments in otoliths. In this regard, the growth of P. filamentosus remains the topic of ongoing study, as is the growth of other bottom fish species. Furthermore, more extensive length-frequency samples of these fishes would have been desirable.

The results of these stock assessments have shown that the bottom fish resources of the main Hawaiian Island are currently being intensively exploited and yet further expansion of the fishery into the NWHI appears feasible on biological grounds. Ancillary studies concerning the diets and fecundities of selected bottom fish species are also currently being pursued (Uchida et al. 1979[4]) and these should assist in the management of bottom fish stocks.

C. Hawaiian Monk Seal and Green Turtle

Both the Hawaiian monk seal and the green turtle are protected under provisions of the U.S. Endangered Species Act. Assessing the status of their populations for stock protection and rehabilitation is therefore a major goal of the Honolulu Laboratory.

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[4]Uchida, R. N., B. M. Ito, and J. H. Uchiyama. 1979. Survey of bottom fish resource in the Northwestern Hawaiian Islands. Southwest Fish. Cent. Honolulu Lab., Natl. Mar. Fish. Serv., NOAA, Admin. Rep. H-79-20, 14 p.

The program for assessment of green turtles is in its second year. The long-range objectives are to gather information on reproductive ecology, migratory patterns, growth rates, mortality rates, and other life history characteristics which will lead to an understanding of turtle population dynamics. Mark-and-recapture techniques will be used extensively. Metal flipper tags have been applied by non-NMFS biologists to over 1,100 turtles since 1973, but mostly to adult animals in the NWHI. In 1981 NMFS scientists experimented with tagging of green turtle hatchlings using auto-transplanted tissue plugs. Results were very promising, so in 1982 the Honolulu Laboratory will mark several hundred hatchlings with reversed scute plugs as they leave their nests at French Frigate Shoals.

Honolulu Laboratory research on the Hawaiian monk seal is also in its second year. Past work has been carried on by scientists from the Department of the Interior, the Department of Commerce, and by researchers on contract to the Honolulu Laboratory and to the Marine Mammal Commission.

Part of the 1981 program involved the development and implementation of a recovery plan for the monk seal population, and this included an outline of research needs for stock assessment and an understanding of seal population dynamics. A variety of assessment techniques might be employed, including aerial and ground counts to develop abundance indices and mark-and-recapture methods using natural marks, bleach marks, or tags.

During 1982 a pilot tagging project at Lisianski Island will be undertaken to test the suitability of plastic cattle tags applied to the hind flippers of about 15 weaned monk seal pups. The tagged pups will also be bleach marked, as will an equal number of untagged pups. Data will be collected on temporal and spatial aspects of haul-out behavior, inter- and intra-specific interactions, and on other aspects of their early life history. If the effects of the tagging procedure and the presence of the tags are judged to be insignificant, a pup tagging program throughout the breeding range of the Hawaiian monk seal will be proposed for 1983.

Tags may also be applied to adult seals in future research. The tagging studies will produce critical information on age- and sex-specific mortality rates, age at first reproduction, reproduction rates, interisland movement, and population size.

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REPORT OF THE SQUID WORKSHOP

Sponsored by
Southwest Fisheries Center Honolulu Laboratory
National Marine Fisheries Service, NOAA
Honolulu, Hawaii
and
University of Hawaii Sea Grant Program
Honolulu, Hawaii
16 February 1982

Southwest Fisheries Center Honolulu Laboratory
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INTRODUCTION

In recent years there has been a growing interest by the domestic fishing industry in the southeastern and northeastern United States in the potential for a squid fishery in their respective areas. In Hawaii also the National Marine Fisheries Service's (NMFS) Southwest Fisheries Center (SWFC), Honolulu Laboratory has demonstrated its interest in squids by initiating in January 1981, a cooperative squid research venture with the University of Hokkaido, which included a series of squid assessment cruises in Hawaiian waters. To more fully understand the status of squids in the marine ecosystem around Hawaii, the NMFS Honolulu Laboratory, with support from the University of Hawaii Sea Grant Program, held a squid workshop on 16 February 1982 at the Honolulu Laboratory. The workshop was timed to take advantage of the presence in Honolulu of Dr. Tsuneyoshi Suzuki, Faculty of Fisheries, University of Hokkaido, an acknowledged expert in squid fishing and research. The workshop was co-chaired by Dr. Suzuki and Mr. Richard S. Shomura, Director, Honolulu Laboratory.

The workshop agenda is shown in Appendix 1 and the participants are listed in Appendix 2.

PROCEEDINGS

I. Opening Address

Mr. Shomura welcomed the participants to the workshop. He gave a brief account of the background of the cooperative squid research venture between the Honolulu Laboratory and the University of Hokkaido and suggested that the workshop focus on three major areas:

(1) The status of squid fisheries in the Pacific basin with emphasis on Hawaii.

(2) Results of the first two cooperative research cruises in Hawaiian waters.

(3) The future (need and strategy) of squid research in the Hawaiian and Northwestern Hawaiian Island (NWHI).

II. Status of Squid Fisheries in Pacific Basin

A. Eastern and Central Pacific

Mr. Walter M. Matsumoto, SWFC Honolulu Laboratory, presented background information describing the present squid fisheries in the eastern and central Pacific. The three fisheries he mentioned were those off California, Hawaii, and Peru. The California fishery, which is by far the largest squid fishery in the United States, landed 1,200-9,000 metric tons (mt) annually between 1950 and 1967. Since 1967 the landings have averaged 11,000 mt, reaching highs of 17,000 mt in 1978 and 16,000 mt in 1979. The squid taken was reported as the common market squid, Loligo opalescens. A few tons of jumbo squid, Dosidicus gigas, have been landed occasionally from southern California, but not in large enough quantities to sustain a fishery.

Mr. Matsumoto further reported that the California fishery was essentially two fisheries: The first, off Monterey with annual landings of 3,000-9,000 mt in the 1963-74 period, which dropped to 2,000 mt in 1975 and 1976; and the second, located mainly around the islands off the Los Angeles area with annual landings of 3,000-8,000 mt. The catches at Monterey were made almost entirely by lampara nets, since purse seines were outlawed by the State and in the Bay area in 1953 and the use of lights to attract and aggregate squids was banned in 1959. The latter action practically eliminated the use of brail in the Monterey fishery. In the southern California fishery, the catches were made mostly by purse seines (80-95% in most years), but in some years, as much as 56-66% of the catches were made by power-assisted brail, used in conjunction with attracting lights.

Part of the squid catches in California was canned with nearly all of the canned product being exported to Europe, Latin America, and the Orient, particularly the Philippines, and part of the catch was utilized domestically as frozen food products and as bait in both commercial and recreational fisheries. In 1976 California canned 3,299 mt of squid and processed 3,076 mt as frozen or fresh products. The remaining 3,000 mt were most likely used as bait.

Mr. Matsumoto reported that the only other fishery for squids in the eastern Pacific was that off Peru, which had an annual catch of 1,092 mt in 1976, but is now around 250 mt. The catches there were composed mostly of Loligo sp. He also reported that

the squid fishery in Hawaii was small, with annual catches of about 3.6 mt. Of this total, 3.2 mt were reported from the island of Hawaii and 0.4 mt from Kauai. Nearly all of the catch, 3.4 mt, were taken by handlines.

During the discussion that followed, it was brought out that experimental fishing by the Japanese in the Gulf of Mexico in 1971 was a stimulus for the development of a fishery for D. gigas in Mexico. The abundance of squids off Chile in some years was mentioned; however, the prospect of developing a squid fishery there in the immediate future was discounted, since squids are reportedly not favored by the population.

B. Western Pacific

Dr. Suzuki presented the status of the squid fishery in Japan, where the most intensive utilization of the cephalopods is being practiced. In 1968 the cephalopod catch by Japan was 887,000 mt, which was almost 10% of the total Japanese catch of all marine animals and represented approximately 72% of the total world cephalopod catch of 1.2 million mt. He stated that the most important species taken was Todarodes pacificus, which yielded annual catches ranging from 200,000 to 700,000 mt. In the last few years (up to 1979) the catch has declined to slightly over 200,000 mt.

Dr. Suzuki reported that in the 1940's T. pacificus was exploited by nonpowered boats of 1 to 2 tons. Powered boats of 10 to 30 tons, using many more jig lines and battery-powered lamps were introduced in the 1950's, and 50- to 100-ton boats equipped with motor-driven jigging machines, powerful lights, and quick-freezers were introduced in the 1960's. These were followed by even larger vessels in the 100- to 300-ton class in the 1970's. The rapid development of the fishery was made possible by intensive study of the biology of the species and technological advances in vessel hull and engine design, and particularly in the light-attracting system and the automated jigging machines.

He reported that the study of T. pacificus has far outstripped that of other squid species and has been instrumental in extending the fishery into offshore waters. He cited as an example the development of the offshore fishery in the Sea of Japan, where dense schools appear in the surface layer along the Polar Front formed by the warm Tsushima Current and the cold Liman Current off Korea. The area yielded some 200,000 mt in 1975, but has now fallen to less than 100,000 mt. He further reported that the lifespan of T. pacificus is only 1 year, during which time the squid migrates north in summer from southern Japan to the Kurile Islands and Sakhalin and returns south in autumn and winter. Dr. Suzuki then described the three squid subpopulations in Japanese waters, the first breeding in

winter (December to March), the second breeding in summer (July to August), and the third breeding in autumn (October to December), and the specific route taken by each in the north-south migration.

Dr. Suzuki then focused on another species, Ommastrephes bartramii, harvested commercially in Japan. He stated that this species is distributed widely in the world's temperate and tropical zones, that it grows to about 40.0 cm, and that it is usually found in more offshore waters than T. pacificus. He reported that the main fishing grounds are in the southern part of Hokkaido in the North Pacific, in the transitional zone between the warm Kuroshio and cold Oyashio. The catch of this species increased from 30,000 mt in 1975 to between 120,000 and 150,000 mt in more recent years.

III. Species of Squids in Hawaiian Waters

Dr. Richard E. Young, Department of Oceanography, University of Hawaii, presented information about the species of squids found in Hawaiian waters. He reported that there were about 62 squid species here and that while most of these were small midwater forms, some Cranchia approached 2.7 m (9 ft) in length, while other deepwater forms with gelatinous bodies were as large as 1.8-2.4 m (6-8 ft). He also noted that the giant squid, Architeuthis sp., which grows to 7.6 m (25 ft) or more, was occasionally taken, but this species was not very good eating. He described the following edible species as being present in Hawaii:

(1) Sepioteuthis (loliginid) - A good eating squid growing to about 60 cm, but not common in shallow waters.

(2) Thysanoteuthis rhombus - A squid that appears occasionally and is believed to be responsible for the large masses of eggs seen floating on the ocean surface. It is extremely tasty and grows to about 1 m.

(3) Onychoteuthis borealijaponicus - In Hawaii only small individuals of this species have been taken occasionally in drift gill nets. Some species of Onychoteuthis are caught commercially in other areas of the Pacific.

(4) Ommastrephes bartramii - A squid that is widely distributed over the subtropical and temperate waters of the Pacific and is caught commercially by the Japanese. It is not uncommon in Hawaiian waters, where large individuals over 30 cm have been taken.

(5) Hyaloteuthis pelagicus - A small squid with adults ranging from 4.4 to 8.1 cm or larger. It is generally distributed north of the Hawaiian Islands.

(6) Symplectoteuthis oualaniensis - A squid which occurs in greatest numbers in offshore waters. This is a small to medium squid (generally below 30 cm) which inhabits the tropical and subtropical areas of the Pacific and whose biomass is considered to be extremely large.

(7) Nototodarus hawaiiensis - A species found in inshore waters during summer, particularly off Hilo, where it is fished for and used as bait in the ika-shibi fishery. It disappears in winter and this has led to speculation that it dies after spawning.

Dr. Young also mentioned that Gonatus and Gonatopsis may be of commercial value, but squids of both these genera are not being fished by the Japanese due to poor eating quality.

IV. Role of Squids in Hawaiian Ecosystem

A. Squids as Food of Seabirds

Mr. Thomas S. Hida, SWFC Honolulu Laboratory presented the results of a study of squids regurgitated by seabirds in the NWHI from 1978 to 1981. A total of 4,315 samples from 18 seabird species from Oahu, French Frigate Shoals, Pearl and Hermes Reef, Necker, Nihoa, Laysan, Lisianski, Midway, and Kure Islands were processed. Squids were found in samples from all 18 seabird species. They were not considered important in the diet of the blue-gray noddy and the gray-backed terns, but were considered the most important prey items for the Laysan and black-footed albatrosses, sooty storm petrel, Bonin petrel, Christmas shearwater, wedge-tailed shearwater, and sooty tern. Importance was determined by a ranking system which considered total numbers, percent frequency, and average of percent volumes of each prey item in each sample.

Mr. Hida reported also that most of the identifiable squids were of the Family Ommastrephidae, of which the bulk were Symplectoteuthis. Symplectoteuthis oualaniensis was the most abundant species, followed by S. luminosa and a few Hyaloteuthis pelagicus. Other squids present in the samples in lesser amounts and lower frequencies were of the Families Cranchiidae, Lepidoteuthidae, Mastigoteuthidae, Onychoteuthidae, Histioteuthidae, and Octopoteuthidae. In addition, he stated that large numbers of beaks were found most frequently in the Laysan and black-footed albatrosses; the highest number, representing 171 squids, was from a Laysan albatross.

Most of the measurable squids had mean mantle lengths ranging between 50 and 100 mm and the largest squid measured was a 208-mm specimen from a red-footed booby. Even larger squids, with mantle lengths estimated in excess of 300 mm, on the basis of beak size, were eaten by albatrosses.

During the discussion that followed, it was noted that Nototodarus was not listed among the squids consumed by seabirds, and a suggestion was made to extend the sampling to the area off Hilo. However, the bird population there was considered small and difficult to sample, since nesting occurred predominantly along the face of cliffs and sharp drop-offs. To a question concerning marine mammals as possible predators of squids, Mr. William G. Gilmartin, SWFC Honolulu Laboratory, stated that monk seals were not feeding on squids in the NWHI area and suggested the porpoise as a possible predator.

B. Squids as Bait in Ika-Shibi Fishery

Mr. Walter N. Ikehara, SWFC Honolulu Laboratory, discussed the squids as bait in the ika-shibi fishery off Hilo. He pointed out that the ika-shibi fishery landed 816 mt (1.8 million lb) of yellowfin tuna, 44 mt (96,000 lb) of albacore and 29 mt (64,000 lb) of bigeye tuna in 1980, valued at $2.8 million, and that the amount of squid used as bait was 2.6 mt (5,632 lb), valued at $4,300. He reported that although squid was reported to last longer as bait than opelu, most fishermen preferred the latter. However, squid was used as bait whenever it was caught. Fishing for squid was done at a maximum depth of 55 m (30 fathoms) with the aid of a 25-W incandescent lamp placed underwater near the surface. Symplectoteuthis oualaniensis was the most prevalent species observed in November, with the largest being about 28- to 30-cm mantle length. The typical squid catch, however, consisted of smaller sizes. He also reported that a few Thysanoteuthis were also caught occasionally during his observation. Mr. Ikehara reported that the squid fishery off Kauai was seasonal, as in Hilo, and that the catches were centered off Port Allen during the summer and fall months.

V. Results of Cooperative Squid Research

Mr. Matsumoto presented the results of the two Honolulu Laboratory-Hokkaido University cooperative squid cruises made in Hawaiian waters in January-February 1981 and 1982. Fishing on both cruises was done with automatic squid jigging machines, supplemented by handlines, rod and reels, drift gill net, and midwater trawl. For the most part, 3 jigging machines, each consisting of 2 lines with 30 jigs spaced 1 m apart on the first 30 m of line, were fished on the first cruise and 4 machines were fished on the second. The machines were set to fish at maximum depths of 40 to 80 m. The gill net consisted of 64 shackles of monofilament net, with mesh sizes ranging from 25 to 233 mm. Units of 3 shackles of each mesh size were arranged randomly by mesh size with both ends of the string consisting of 5 shackles of 121-mm mesh nets. The midwater trawl had a mouth opening of 15 x 15 m and a cod end made of 2-mm square mesh liner.

Mr. Matsumoto reported that on the first cruise (1981), 661 squids were caught at 15 stations by jigging and fishing with handlines and rod and reels around the main Hawaiian Islands between Lanai and Kauai. The best catches (100-200 squids per station) were obtained in calm seas south of Oahu and Lanai, where the bottom was 900 m or greater. Stations fished in rough seas resulted in less than 20 squids per night. Only 11 squids were caught in the NWHI where 4 stations were fished for 1 to 2 hours only. Mr. Matsumoto noted that S. oualaniensis comprised the bulk of the catch for the entire cruise (659 squids), with the remaining catch consisting of 12 O. bartramii and 1 N. hawaiiensis. Mantle lengths of squids caught by jigging ranged between 10.0 and 26.0 cm and all squids over 28 cm were taken on rod and reel. He further reported that 8 gill net stations yielded 9 S. oualaniensis (13.5-25.5 cm), 5 O. bartramii (22.3-35.5 cm), and 3 Onychoteuthis borealijaponicus (8.5-10.6 cm). Two midwater trawl hauls with the net towed at 100 and 600 m in the afternoon off Penguin Bank failed to catch any squid.

On the second cruise (1982) 14 automatic jigging stations produced 135 squids, all S. oualaniensis, of which 8 were caught by rod and reel. No squid was taken at 2 stations, both stations in depths of less than 600 m. Six large squids estimated at 75 to 100 cm and identified as Thysanoteuthis were observed at the surface off Kaneohe at one of the shallow stations. The poor catches on this cruise were probably due to continuous rough seas and winds of 18-15 knots throughout most of the sampling period.

Mr. Matsumoto noted that the gill net catches were about the same as that obtained on the first cruise. The catch included nine S. oualaniensis, three O. bartramii, and four Onychoteuthis spp. Four hauls with the midwater trawl, with the net towed well above and in the deep scattering layer, produced 53 small squids, all less than 50 mm, representing the genera Abralia, Abraliopsis, Cranchia, Eledonella, Heteroteuthis, Histioteuthis, Hyaloteuthis, Leachia, Liocranchia, Megalocranchia, Onychoteuthis, Pyroteuthis, and Sandalops.

Mr. Matsumoto ended his presentation by saying that on the basis of size alone, both S. oualaniensis and O. bartramii could be likely candidates for commercial development and that the small catches obtained on the two cruises were likely due to poor fishing conditions and unfavorable seasonal timing. He noted that the near absence of N. hawaiiensis, one of the species taken in the ika-shibi fishery during summer and a likely candidate for commercial development, may well have been due to unfavorable timing also.

VI. Biological Results of First Cooperative Cruise

A. Analysis of Squids Caught

Dr. Suzuki presented the results of some of the analyses made of the squid data collected on the first cruise. Of 400 squids

(S. oualaniensis) analyzed, about 25% (99) were males and 75% (298) were females. Of the males, 9% (9) were immature, 8% (8) were maturing, and 82% (81) were mature. Of the females, 96% (286) were immature and 4% (12) were mature. A further breakdown of the females indicated that of the immature group, 9% (26) showed signs of having undergone coition, 90% (257) had not, and 1% (3) was undetermined; and of the mature group 50% (6) showed positive signs of coition, 42% (5) were negative, and 8% (1) were undetermined. Males with evidence of coition ranged in sizes from 10.0 to 17.8 cm, with a mean of 13.9 cm; whereas the lengths of females ranged from 11.0 to 25.0 cm, with a mean of 15.5 cm. Dr. Suzuki noted that males of S. oualaniensis in Hawaii matured at smaller sizes than females, not unlike T. pacificus taken in Japanese waters.

Dr. Suzuki also reported that there were significant positive correlations ($P = 0.05$) between liver weight and mantle length, liver weight and body weight, and liver weight and gonad weight in both males and females grouped in coition B category.

B. Gonad Studies

Dr. Young presented preliminary results of a study conducted aboard the Hokusei Maru on the first cruise in collaboration with Dr. Raymond Hixon, Universty of Texas-Galveston. Dr. Young reported that the study was done to determine whether S. oualaniensis spawn more than once during the season. From their examination of gonads and oviducts they noted (1) that the fully matured squids ranged widely in sizes; some were mature at 20 cm, while others were mature for the first time at 30 cm, (2) that unlike squids in temperate waters, where spawned-out individuals have no eggs remaining in the ovary, squids that spawn in Hawaiian waters had eggs remaining in the ovary, some with the ovaries fully packed, (3) that the oviduct was a repository for eggs freed from the ovary, (4) that this species of squid spawns as the oviduct fills up, (5) that there was no evidence that the ovaries decreased in size as eggs were spawned, and (6) that, as expected, there was no significant correlation between egg volumes in the oviduct and mantle length.

Dr. Young felt that some squids they had examined were not mature for the first time, i.e., that they may have spawned before.

On the basis of these findings, Dr. Young believed that this species spawns continuously throughout the season in Hawaiian waters but that further work was needed to determine this more conclusively. He reported that Dr. Hixon is now in the process of examining the size frequencies of eggs in the ovary for additional evidence of multiple spawning.

VII. Future Squid Research in Hawaiian Waters

Mr. Shomura led the discussion on the future of squid research in Hawaiian waters. The discussion dwelled on the following points:

(1) State of knowledge of squids in Hawaiian waters.--It was felt that the identification of squids was fairly well in hand for Hawaiian waters, but that there was practically no information on spawning, spawning grounds, growth, and other aspects of squid life history and biology. Much of this was due to the lack of effort and the difficulty of obtaining squids in the younger stages up to the sizes taken by jigging. It was pointed out that extension of sampling in the NWHI will introduce yet another species of Symplectoteuthis, of which equally little is known.

(2) Sampling for squids.--To overcome the difficulty of obtaining squids for study, it was suggested that sampling be done off Hilo, since low cost support could be available from the ika-shibi fishing boats and because of the occurrence of both S. oualaniensis and N. hawaiiensis there.

It was further suggested that the Townsend Cromwell be used for squid sampling, particularly during the summer, to complement the winter cruises made by the Hokusei Maru. It was felt that the use of the Cromwell would lessen the objection by ika-shibi fishermen to squid research in local waters. The sampling gear recommended for the Cromwell included at least one or two automatic jigging machines, rod and reel or handline, gill net, and midwater trawl.

(3) Catches by the Hokusei Maru.--The small catches obtained on the two Hokusei Maru cruises were questioned. Dr. Suzuki responded by saying that the methods of sampling used were identical to gear used commercially in the Japanese squid fisheries. He felt that the clarity of the water here was largely responsible for the poor catch, since at many jigging stations squids were seen to pursue a jig to the surface, stop a few inches away, and depart, without attempting to take the jig. To improve the catch, chumming with bait during jigging was suggested.

(4) Future cruise by the Hokusei Maru.--The outlook for next year's Hokusei Maru cruise was discussed. Dr. Suzuki commented that they had committed the ship for this venture for 3 years and will honor their commitment. He suggested fishing off Kona or Hilo rather than to repeat fishing in the same areas fished on the past two cruises. A suggestion was made to fish off Pepeekeo and Kumakahi Point, Hawaii; however, this was not considered feasible with the Hokusei Maru because of the strong objections certain to be voiced by the Hilo fishermen, as they had done prior to the first cruise. Mr. Shomura felt that any work in the vicinity of local squid fishing areas would best be done with our own vessel.

APPENDIX 1

AGENDA

0900 - Opening remarks (R. Shomura)

0910 - Status of squid fisheries in the Pacific basin (W. Matsumoto and T. Suzuki)

1020 - Species of squids in Hawaiian waters (R. Young)

1030 - Importance of squids in the Hawaiian ecosystem (T. Hida and W. Ikehara)

1100 - Results of two cooperative squid research cruises (W. Matsumoto)

1200 - Lunch

1330 - Biological results of first cooperative squid research cruise (T. Suzuki and R. Young)

1500 - Open discussion on future of squid research in Hawaiian waters (R. Shomura)

1545 - Summary and closing remarks (R. Shomura)

(5) Alternate sampling strategy.--Alternate strategy to best sample squids in local waters was discussed. It was noted that squids are known to be fairly localized in certain areas, such as off Pepeekeo. Suggestions were made that the area be examined for any signs of unusual oceanographic features or to look for other areas with local upwelling and to concentrate sampling in such areas.

VIII. Summary

Mr. Shomura summarized the proceedings of the workshop. He touched upon the topics discussed, the general lack of information about growth, mortality, stock assessment, and other aspects pertaining to squids in local waters, and on the need for some preliminary work in areas off the island of Hawaii. He mentioned that some work on squids was in the Laboratory's plans in the near future, that he hoped to get the Cromwell to do some squid fishing next winter prior to the ship's departure for the west coast, and that he hoped the Hokusei Maru returns again for another cruise.

Submitted by:

Tsuneyoshi Suzuki
Co-Chairman

Richard S. Shomura
Co-Chairman

APPENDIX 2

LIST OF PARTICIPANTS

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MICROCOMPUTERS AND FISHERIES

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I. INTRODUCTION

Research and management relating to living resources require extensive data bases. Because of the multiplicity of species, fishing gears, and participating nations, fisheries research and management activities may require many more data than any other resource management area. This situation led fisheries scientists and managers to embrace good record keeping practices and to apply statistical survey procedures. The resulting large depositories of data contributed materially to the development of quantitative techniques for fishery stock assessment in the early 1900's. The ever increasing size of the data sets created problems in processing and managing them in a timely and cost efficient manner. With the development of the computer during World War II and its commercial availability shortly thereafter, a new tool became available for managing and processing these large fisheries data sets.

Fisheries workers adopted this new tool, learned high-level programming languages, such as FORTRAN, to process their data, and proceeded in an effort to gain access to ever bigger, more powerful mainframe computers.

In the middle to late 1970's, developments occurred in the computer field that are only now being recognized and adopted to any great extent in fisheries. These developments include: 1) maintenance of data sets in mass storage devices (disks) attached directly to computers rather than on magnetic tapes to facilitate speedy access for updating or analysis; 2) interactive rather than batch processing; 3) availability of smaller computers called minicomputers; and 4) time sharing of processing resources on a mainframe computer.

Two recently occurring computer developments are not, except for a few instances, being used in fisheries. One involves a concept called distributed processing, where two or more small computers perform site specific processing but are linked together in a network for sharing of data bases, and sometimes, the processing power of a central, large computer. The second event, which is the subject of this paper, involves the development of the general purpose microcomputer.

In this report, I will describe the general purpose microcomputer, discuss its capabilities, compare its performance specifications to some minicomputers, and finally present some fisheries applications of microcomputers.

In discussing computers, it will be necessary to use words and terminology unfamiliar to most fisheries workers. To make matters worse, the computer field is rich in jargon that is evolving as rapidly as the field itself. I will attempt to avoid as many of the specialized terms as possible but the use of some will be necessary. To facilitate our communication, I have included a short glossary (Appendix 1), which I extracted mostly from McGlynn (1979) and Popular Computing (1981).

II. THE MICROCOMPUTER

A. Some Definitions

What is a microcomputer? And, what makes it different from the computers we fisheries scientists have been using all these years? The glossary presents the text book definition, but further explanation seems in order.

A computer system, besides essentially being an assemblage of machines whose purpose is to process information, is made up of several devices--some for inputting information, some for storing it, some for outputting it, and one for processing it. The latter is generally called the central processing unit (CPU). It is the heart of the computer and is purely electronic, not electro-mechanical. The CPU is in turn made up of an arithmetic logic unit, some registers for temporary storage of data, instructions, and address (much like the registers on a calculator), an instruction decoder and timing unit (determines what part of the CPU is instructed to do something and when), sometimes a clock, a memory and input-output controller (for communicating with random access memory and the input-output interface), and communication wires (called buses; for transmitting data, addresses, and control instructions).

Large mainframe computers or maxicomputers, for example the IBM,[1] Univac, and Burroughs machines which have been used for so many years, are products of the electronics industry. In these machines, the CPU is made up of separate electronic units linked together inside a cabinet to accomplish each of the functions of the CPU given above. These units or boxes have gotten smaller over the years, but they are still separate electronic units. In minicomputers, a great advancement was made in miniturization so that the arithmetic logic unit, the registers, and the instruction decoder and timing unit could be placed together on an electronic board. These electronic boards not only take less space than the electronic units of the maxicomputers, but they are cheaper to manufacture and are more dependable.

Microcomputers are products of the semiconductor industry and are fundamentally different from both mini- and maxicomputers. In this case, all of the processing functions of the CPU are placed together on a single silicon chip smaller than your fingernail. Hence, the phrase "computer on a chip." Technically, the silicon chip is a microprocessor. This chip is placed on an electronic board along with part or all of the random access memory, the clock, the input-output interfacing unit, and extensions of the communication buses. Hence, the entire CPU can now reside on a single electronic board although frequently part of the random access memory is placed on a separate board. This arrangement is cheaper to manufacture and more dependable than that used in the minicompter.

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[1]Reference to trade names does not imply endorsement by the National Marine Fisheries Service, NOAA.

Thus, the basic difference among maxi-, mini-, and microcomputers is the electronic architecture. What about using processing capacity as a means of defining these types of computers? In general the maxicomputers are capable of doing more processing faster than mini- or microcomputers. However, as minicomputers improved, they became capable of performing the same work in less time and at less cost than smaller, less capable maxicomputers. Hence, the more efficient minicomputers have displaced the less efficient maxicomputers from the market place. Similarly, advances in microcomputers have resulted in the displacement of the smaller less capable minicomputers. Today, a microcomputer costing US$2,000-3,000 is more powerful, faster, and more compact than the first computer costing millions of U.S. dollars. The processing power of each of the computer types is advancing rapidly and will continue to do so for the foreseeable future; hence, processing power is not a good means for characterizing types of computers.

B. Some Early Uses

The microprocessor was originally created to handle routine, set tasks commonly used in controlling manufacturing processes. It was only later that the microcomputer, encompassing the microprocessor, was used for manufacturing, business, and scientific applications. Some of the first applications of microprocessors in science were to interface between laboratory or field instruments and some recording device or a computer. In fisheries and oceanography, microprocessors are used with instruments measuring temperature, conductivity, pressure, current, and weight. In such instruments, they can be used to control the rate at which the sensory instruments operate, to convert the devices' analog signals to digital signals for subsequent analysis on computers, and to filter, smooth, or average data generated by sensory instruments. They calculate salinity from temperature, pressure, and conductivity readings and the position of ships from satellite signals (see Mini-Micro Systems 1979 for a description of a forerunner to the off-the-shelf satellite navigation instruments that are available today). They can be used to estimate the potential amount of naturally occurring fish food by counting free-fall particles (Lasker and Brown 1978).

Increasingly, microcomputers, rather than microprocessors, are being built into laboratory and field instruments because they can be programmed to handle variable situations including the changing of work performed by the instruments in response to changes in the factors being measured. For this reason, microcomputers are being employed in oceanographic data buoys (Lobecker et al. 1978), in unmanned underwater vehicles (Marine Industrial Advisory Service 1980), and echo-sounder integration systems to estimate fish abundance (Kanemori and Ehrenberg 1978; Iida and Suzuki 1980). Although these machines are programmable, they are essentially dedicated to one particular kind of task.

C. The General Purpose Microcomputer

Of greater significance to fisheries workers today is the availability of powerful, but relatively inexpensive, general purpose

microcomputers. Sometimes they are called desk top computers, but the largest reside in cabinets. Most are 8 bit machines (that is, they use eight binary digits consisting of either 0's or 1's to represent numeric data, alphabetic letters, and special characters) although 16 bit machines are becoming more common. Some of these microcomputers are capable of supporting several users whereas others only one user. The latter are called personal computers.

In the following paragraphs, I will state some of the advantages of personal and multiuser microcomputers, comment on available computer programming languages, describe several commercially available computer program packages, and end with some brief material on communicating with other computers and sensory instruments.

The great advantage of a personal computer is that it is available for immediate use at any time for nearly any application the user wishes. Unlike users of large computers, the personal computer user does not contend with slow response time or inability to gain access to the computer because too many users are on the system. Neither is the user of a personal computer subject to processing expenses or operator imposed restrictions associated with large computers.

The multiuser microcomputer also has several advantages. Since such computers are usually dedicated to a small group of associated users rather than to some organization-wide support group, they are available for use at the convenience of the group. Computer programs and data sets can easily be shared. Peripheral devices, such as disks, a printer, and a graphics plotter can be shared, thus lowering the overall cost. Of course, only one user can utilize these peripherals at any one time.

BASIC is the most commonly used programming language, but many microcomputers can be programmed in several other high-level languages such as FORTRAN, COBOL, and PL/I. In addition, several new structured programming languages, for example, Pascal, are becoming available for microcomputers. High-level languages allow the user to program the computer to perform almost any type of processing task imaginable.

Many new computer programs (or software) are becoming commercially available that significantly increase the utility of these machines to fisheries workers. Previously, software for data entry, file management, and data base management were available only on mainframe computers. Without such software for microcomputers, it was very laborious to enter data and manage the data sets for subsequent analysis. Now, there are several commercially available software packages for microcumputers that allow the user to set up data entry formats, manage individual data sets, or combine data sets or elements from several data sets for subsequent analysis. While these currently available packages are not as powerful as those for mainframe computers, they have significantly increased the usefulness of the microcomputer and the productivity of its users. With more powerful 16 bit microcomputers becoming available, this situation should improve.

Some statistical software packages exist for performing simple parametric and nonparametric analyses including time series analysis. However, these packages generally are not very powerful because of limited machine memory, language-based restrictions on the number of significant digits that can be carried in calculations, and poor data entry and management procedures. Very few quantitative fisheries applications have been programmed onto microcomputers, but it should be fairly straight forward to do so. Again with the entry of more powerful 16 bit microcomputers, more sophisticated statistical software should become available, and it should be possible to program all but our most complicated stock assessment methodologies onto these computers.

Most of the statistical software also have the ability to plot the data used in the analyses and the results from the analyses. Needs in the business world have resulted in software capable of producing pie charts and bar graphs, in color if you wish. Needs in the automotive, aircraft, and communications industries have resulted in the development of graphics software capable of displaying three dimensiontional charts, expanding views of selected areas of a display, rotating figures, and changing the angle of view. Thus, the available software is probably capable of handling any fisheries application; but the technology must be transfered to fisheries. Graphic representations of data can be displayed on monochrome or color video terminals or can be sent to graphics printers or plotters. The cost of these devices, particularly graphics printers, has decreased substantially in the last couple of years, thus making them available to many more users. Relatively inexpensive color graphics printers are now available.

The microcomputer industry has created a unique type of software that has not as yet been implemented on larger computers. This software allows the user to set up a grid of columns and rows that can be mathematicaly interrelated according to the user's specifications. If the user wishes to see the consequences of changing some of the numbers entered into the spread sheet, he merely enters the new numbers and the rest of the table is recalculated. Thus, simple simulations can be programmed in minutes rather than hours using regular high-level languages.

The last type of microcomputer software that I will discuss, word processing, has tremendous utility in fisheries. Although this software accomplishes a task that is technically not part of fisheries or any science, word processing can reduce the time spent writing scientific documents. To produce this paper, I outlined what I wanted to say, collected information from the literature to supplement what I wanted to say, prepared a more detailed outline, and then sat down in front of a microcomputer and wrote the paper. The software allowed me to edit various sections, make insertions, and move whole sections around before I was satisfied with the document. When I passed the text file containing the document to the secretarial staff for finalization, they did not have to decipher cross outs, insertions, and arrows pointing in various directions. When they finished their work, I did not have to check for introduced typing errors. It is much easier and faster to prepare documents using word processing than by any other method. Word processing can be

accomplished on microcomputers, dedicated word processors, or mainframe computers, but these latter devices are less available to individual scientists.

Devices called modems and the software to support them allow the user of a microcomputer to communicate with other microcomputers or with mainframe computers. This facility essentially turns the microcomputer into a terminal which can then be used to transfer data sets to or from a mainframe computer and to conduct analyses directly on the larger computer. In addition, software is available for some microcomputers making it possible for them to function as a remote job entry station to a mainframe computer (2780/3780 protocol emulator). The capability of a microcomputer to emulate a terminal or a remote job entry station is extremely useful because it allows the microcomputer user to manage and process very large data sets on the mainframe computer and then use the microcomputer to process compacted data retrieved from the larger computer.

Most general purpose microcomputers have the ability to interrupt ongoing processing and interrogate scientific measuring instruments, store or process the data received, and then return to the other task it was performing. Thus, the microcomputer can be used to control or conduct experiments while still being used as a data processing computer.

D. Comparing Microcomputers and Minicomputers

In the material presented above, I called the microcomputer a powerful tool and discussed some of its capabilities in terms of available software for data processing. To put things into perspective, I will compare specifications and costs for the basic hardware comprising a minicomputer and a microcomputer. For this comparison, I will use two tables listing the features of several minicomputers that were prepared by the International Commission for the Conservation of Atlantic Tunas (ICCAT) in 1978 and the Food and Agriculture Organization (FAO) Project for Tuna Management in 1980. The minicomputer procured by the Skipjack Assessment Programme of the South Pacific Commission (SPC) is included in these tables. The microcomputer used in the comparison is produced by Integrated Business Computers, a relatively small manufacturer in the U.S. Although this is a sophisticated system, it is not unique in the United States, Japan, or Europe.

In 1978 the SPC acquired a Hewlett-Packard (HP) 1000 model 45 minicomputer to support their tagging activities. At the time, this computer represented the state of the art for midrange minicomputers. In the same year, ICCAT prepared a paper comparing the capability and cost of several minicomputers (including the HP 1000) to the costs of time share services from Computer Sciences Corporation's Information Network (Nordstrom and Miyake 1978). The hardware specifications and costs for the minicomputers are reproduced in Table 1. In 1980, FAO's Project for Tuna Management prepared a similar table comparing the features and costs of minicomputers for consideration by the tuna committees of the Indo-Pacific Fisheries Commission and the Indian Ocean Fisheries Commission (Skillman

1980). By today's standards, these minicomputers (Table 2) no longer represent the state of the art, and they fall into the lower range of the capability of minicomputers.

It can be seen from Tables 1 and 2 that the cost of these systems has decreased substantially. In 1978, the cost of the basic HP system was nearly US$100,000. The least expensive system, the IBM, cost about US$88,000; the most expensive, Digital, cost US$106,000. By 1980, HP had become the least expensive system, costing only about US$58,000. The most expensive was the FACOM at over US$91,000.

From Table 3, it can be seen that the IBC microcomputer compares favorably with the minicomputers listed in Tables 1 and 2 in terms of central processor memory (its maximum memory is significantly less than the largest of the minicomputers, however), cycle time (a measure of internal speed; significantly faster than any of the minicomputers), and disk storage capacity. The manufacturer's specifications did not give the density of the 9 track tape drive, but it is probably no more than 800 bits per inch (bpi), which is the same for the minicomputers listed in Table 1. Also, the disks may be slower than those used with minicomputers. Specifications are not the whole story, but this 8 bit microcomputer does compare reasonably well with the minicomputers listed.

For a number of years now, the 8 bit microcomputer has been dominating the market; however, the microcomputer field is undergoing a revolution because of the introduction of the 16 bit microprocessor. Today there are at least 20 microcomputers using these more powerful microprocessors. These new microcomputers are not only faster, but more importantly they can directly address much more memory (1.0 Mbytes or more as compared to 64 Kbytes). All or most of the minicomputers listed in Tables 1 and 2 are 16 bit machines. As the manufacturers of 16 bit microcomputers improve their products and make them more sophisticated, the 16 bit microcomputers will undoubtedly displace minicomputers of the level discussed here. In addition, two manufacturers have announced 32 bit microprocessors, and one indicated that manufacturing would start in 1983.

III. RECENT FISHERIES APPLICATIONS USING MICROCOMPUTERS

General purpose microcomputers are being used in fisheries to an increasing extent, including the central and western Pacific. As an illustration of this, I will present below the three recent applications.

A. Western Pacific Fisheries Information Network

With the passage of the Magnuson Fishery Conservation and Management Act in 1976, Federal and State fisheries managers have experienced an increasing need for data on fisheries resources in the U.S. Fishery Conservation Zone. Accurate data are needed on a timely basis for management decisions and the preparation of fishery management plans. Managers and scientists in the National Marine Fisheries Service (NMFS), the Western Pacific Regional Fishery Management Council, and state and territorial fisheries agencies have encountered problems due to the lack of a historical data base, unavailability of existing data for analysis, legal

constraints for data exchange, lack of data standardization, and inadequate procedures for data collection. The Southwest Fisheries Center started the Western Pacific Fishery Information Network project to solve these problems.[2] Specifically, the purpose of the project is to 1) enhance and modernize the existing systems for fisheries information management and data collection; 2) develop and implement new systems for information management and data collection; 3) establish both central and distributed, computerized data bases; and 4) establish a communication network among state, territorial, and Southwest Fisheries Center data collection and processing groups for access to and exchange of the computerized data bases. The agencies included in the network are in addition to the Honolulu Laboratory of the Southwest Fisheries Center, the American Samoa Office of Marine Resources, the Northern Mariana Islands Department of Natural Resources, Guam Division of Aquatic and Wildlife Resources, and Hawaii Division of Aquatic Resources.

The network is a distributed computer system consisting of a central minicomputer and satellite microcomputers (Figure 1). The central minicomputer system consists of a Digital Equipment Corporation PDP 11/70 accessed on a time share basis using video display terminals or a microcomputer. The distributed microcomputer systems consist of Apple II Plus microcomputers each with twin 5-1/4 inch (13.3 cm) floppy disk drives, a dot matrix printer, and a video screen. Micromodems are included with the microcomputers located at the Honolulu Laboratory and the Hawaii Division of Aquatic Resources.

A similar network is being set up by the National Marine Fisheries Services' Southeast Fisheries Center for essentially the same purpose. This network will involve all the States in the southeastern U.S. and will include data on fisheries resources under U.S. jurisdiction in the Gulf of Mexico, the Caribbean, and off the southeast Atlantic coast.

B. Resource Assessments in the Indo-Pacific Region

The International Center for Living Aquatic Resources Management (ICLARM) is conducting several studies involving the assessment of demersal and pelagic fish stocks in Southeast Asia. Recently, Pauly (1981) indicated that they are establishing a microcomputer-based system for filing trawl survey data on fisheries in the region and for their analysis by local scientists. In this same paper, Pauly also announced the availablility of microcomputer software to calculate von Bertalanffy growth parameters and catch curves from length-frequency data.

C. Laboratory Research on Tuna in Hawaii

At the Kewalo Research Facility of the Honolulu Laboratory, microcomputers are being employed in experiments involving physiological

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[2]Hamm, D. C. 1982. Preliminary description of the western Pacific fishery information network. Southwest Fish. Cent. Admin. Rep. H-82-2, 11 p. Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 96812.

parameters, environmental variables such as temperature, feeding preferences and rates, and electromagnetic fields. The microcomputers are interfaced with sensing devices to determine the movement and other behavioral responses of captive animals being subjected to various experimental procedures. The microcomputers are programmed to analyze the behavior of the experimental fishes and alter the experiment in response to the fish's behavior. In this way, the experimental animals' preference for environmental factors such as temperature have been determined. The ability of skipjack tuna, Katsuwonus pelamis, and other tuna to sense changes in the earth's electromagnetic field is being investigated to determine their ability to use this environmental cue for migration.

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APPENDIX 1

Glossary

Analog. In the computer field, the use of electric voltages as physical analogues of numerical variables.

Architecture. Organizational structure of a computing system, mainly referring to the CPU or microprocessor.

BASIC. The most popular high-level language used on microcomputers. Short for "Beginner's All-purpose Symbolic Instruction Code."

Bit. An abbreviation of "binary digit;" single characters of a binary number, either 0 or 1 in the case of computers.

Byte (B). A sequence of n bits operated upon as a unit is called an n-bit byte. The most frequent size is 8 bits. KB stands for 1,024 bytes, and MB stands for 1 megabyte.

Bus. A group of wires that allow memory, CPU, and input/output devices to exchange data.

Clock. In a small computer, a device that sends out timing pulses to synchronize the actions of the computer.

COBOL. Short for "Common Business Oriented Language;" a high-level language.

Computer Program (Program). A collection of instructions properly ordered to perform a particular task.

CPU (Central Processing Unit). That part of a computer system that controls the interpretation and execution of instructions. In general, the CPU contains the following elements: arithmetic-logic unit, timing and control, accumulator, scratch-pad memory, program counter and pointer stack, instruction register and decoder, parallel data and input/output bus, memory and input/output control.

Data Base. The entire collection of information available to a computer system. Or, a structured collection of information as an entity or collection of related files treated as an entity.

Data Base Management System (DBMS). Facilities for creating and maintaining a large, organized, structured collection of data and providing means for producing various types of predetermined reports based upon interrogation of the data base.

Data Set. A collection of data records, with a logical relation of one to another.

Digital. Of or pertaining to numerical bits.

Disk. A round piece of magnetic-coated material used to store data with greater density, speed, and reliability than with magnetic tapes. Floppy disks have thin 5-1/4 inch (13.3 cm) or 8 in. (20.3 cm) disks. Hard disks are thicker and can be much larger.

FORTRAN. A high-level language generally for scientific use, expressed in algebraic notation. Short for "Formula Translator."

Hardware. Physical equipment forming a computer system.

High-Level Language. User oriented programming languages using letters, symbols, or English-like text from which are generated codes the computer understands. FORTRAN, COBOL, and BASIC are three commonly used high-level languages.

Input-Output (I/O). General term for the process of communicating between the computer and external devices; or the data involved in that communication.

Mainframe Computer. A large-scale computer such as the IBM System 370 maxicomputer or a Digital VAX 11/370 minicomputer.

Memory. That part of a computer that holds data and instructions. Each instruction or datum is assigned a unique address that is used by the CPU when fetching or storing the information.

Microcomputer. A computer whose CPU is a microprocessor. A microcomputer is an entire system with microprocessor, memory, and input-output controllers.

Microprocessor. Frequently called "computer on a chip." The microprocessor is, in reality, a set of one, or a few, large-scale integrated circuits capable of performing the essential functions of a computer CPU.

Modem. Short for modulator/demodulator. An electronic device that allows computer equipment to send and receive information through telephone lines.

Network. An interconnected group of computer systems, terminals, or communications facilities for sharing of data bases or computer processing resources.

Peripheral Device. Equipment that is external to the computer itself, for example, disks and printers.

Pascal. A high-level, structured programming language named after the 17th century French mathematician Blaise Pascal.

PL/I. A high-level, structured programming language combining features from COBOL, FORTRAN, and other languages. Short for "Programming Language One."

Software. Computer programs.

Terminal. An input-output device that interfaces between the human operator and the computer system, for example, a teletype or a video display terminal.

Video Display Terminal (VDT). A terminal containing a screen for viewing data entered into or received by the terminal. A cathod-ray tube is most commonly used resulting in the acronym CRT.

Table 1.--Comparison of ICCAT's minicomputer performance and cost[1] (from Nördstrom and Miyake 1978).

System models recommended	DIGITAL PDP-11 Model-34A	$	HEWLETT-PACKARD 1000 Model 45	$	IBM Series 1 Model E	$	TEXAS INSTRUMENTS DS 990/10 Model 4	$
HARDWARE								
Processor								
Memory	128K bytes		120K bytes		128K bytes		256K bytes	
Speed (cycle time)	725 n.s.				660 n.s.		725 n.s.	
Console	Printer (30 cps)		Screen		Screen		Screen	
I/O Devices								
Disks	14MB x 2		9.8MB x 2		64MB x 1		5MB x 4	
Av. access time	50.5 MS		33 MS		36 MS		35 MS	
Diskette magazine unit	—		—		28 MB		--	
Tape unit	800 BPI		800 BPI		—		800 BPI	
Printer	180 cps x 2		180 cps		150 l.p.m. (approximately 200 cps)		150 cps x 2	
HARDWARE COST:		$103,367		—		$77,271		$91,560
SOFTWARE								
FORTRAN IV	Available		Available		Available		Available	
Utilities and sort	Available		Available		Available		Available	
SOFTWARE COST:		2,338				10,656		5,550
TOTAL PRICE		$105,705		$99,989		$87,927		$97,110
OPTIONAL								
Processor								
Memory	Up to 248KB		Up to 2MB (by unit of 128K)	8,071/128K	Up to 256KB	11,743	Up to 2MB	
Card reader	300 c/m	9,500	600 c/m	10,291	Not available		400 c/m	7,800
V D U (Screen)			Available	5,246	Available		Available	
Plotter	Not available[2]		280 x 400 mm	7,743	Not available[2]		Not available[2]	
Software (Data base managing system)	DATATRIEVE-11	6,493	IMAGE/120	$4,571	Not available at present		Available	3,000

[1]Estimates for prices are valid for October-November 1978. Prices are given in pesetas and converted into US$.

[2]Any makes can be adopted.

Table 2.--Comparison of minicomputer performance and cost (from Skillman 1980).

System/Models Specifications	DEC PDP-11/34A	US$	FACOM V-830 6/	US$	HEWLETT-PACKARD HP 1000,Mod 45	US$	IBM Series 1, Mod E	US$	Texas Instruments TI990/10 Model 4	US$	Wang Model 2200 VS	US$
Basic configuration												
Central processor												
Memory	128K	n/c	262K	n/c	128K	n/c	128K	27 200 (operating system)	256K	n/c	128K	n/c
Speed (cycle time)	725 n.s.		400 n.s./2B		420 n.s.		660 n.s.	2 000	725 n.s.		660 n.s.	
Console	printer 30 cps	n/c	screen	n/c	graphics screen	n/c		1 700	screen	n/c	screen	n/c
Cost		54 000		45 700		43 500		30 900		34 500		21 800
Peripherals												
Main storage	disk 28MB (x2)	n/c	disk 40MB disk 40MB(x4)	n/c 9 400	disk 19.6 MB (x2)	n/c	64MB x 1	10 700	disk 5MB (x4)	7 800	disk 75MB (x4)	19 000/ unit
Backup storage	tape 1600bpi	17 000	tape 1600bpi	22 800	tape 800bpi	10 750	tape	17 500	tape 800bpi	10 000	tape 800/ 11600bpi	16 100
Printer	180 cps(x 2)	7 400	180 cps	9 582	180 cps	4 000		8 600	150 cps(x 2)	5 500	220 cps	10 350
Cost		24 400		41 782		14 750		36 800		23 300		45 450
Software												
FORTRAN IV	available	800	available	75/mo.	available	n/c	available 2/	870	available	1 000	available	n/c 3/
Utilities and sort	available	n/c	available	165/mo.	available	n/c	available	720	available	2 500	available	n/c
COBOL	available	?	available	75/mo.		n/a	available	870		n/a	available	3 450
Cost		800				0		2 460		3 500		3 450
Total cost		79 200		91 262		58 250		70 160		61 300		70 700
Options												
Memory up to	256K	4 000	512 KB	3 600/ 128KB	2 MB in 128K	3 500/ 128K	256K	1 510/ 16KB	1 MB	575/ 4Kwords	512K for VS 2 048K for VS 100	8 500/ 128K 10 350/ 128K
Card reader	300 c/m	7 000	600 c/m	17 030	600 c/m	6 375		n/a	400 c/m	5 200		n/a
Video display screen	available	2 200	available	3 862	available	3 500		n/a	available	2 000	available	2 900
X-Y plotter		n/a		n/a		2 600		n/a		n/a	not now available	
Data Base Software		4 500	available	200/mo.		3 000		n/a		2 000	available 4/	n/c
Word Processor Software											available 5/	3 000

1/ Cost estimates were quoted by west coast vendors in U.S.A. and may vary withthe site chosen in Indo/Pacific area.

2/ PL/1 language is also available.

3/ BASIC and PL/1 languages also available; Assembler and one higher order language included with price of system and each additional language cost $3.450.

4/ An advanced DBMS is available for $17 250.

Table 3.--Specifications, performance capability, and cost of an IBC Ensign Model E-1256 microcomputer.

Specifications	Values	Cost US$
Basic configuration		
Central processor		10,850
Memory	256K	n/c
Speed (cycle time)	120 nsec	--
Console	Video	1,300
Subtotal		12,150
Peripherals		
Main storage	2, floppy disks (2.4MB	n/c
	Winchester disk (50MB)	8,200
Backup storage	9 track tape drive	2,250
Printer	150 cps	1,695
Subtotal		12,145
Software		
Basic	Available	290
COBOL	do	580
FORTRAN	do	350
Pascal	do	430
PL/I	do	460
Operating system cp/M	4 different systems	300
Subtotal		2,410
Total		26,705
Options		
Memory up to	768KB	4,200/256KB
Card reader	Not available from manufacturer	
Video display terminals	3 models	800 to 1,300
X-Y plotter	Available from other vendors	
Data base software	do	
Word processor software	do	

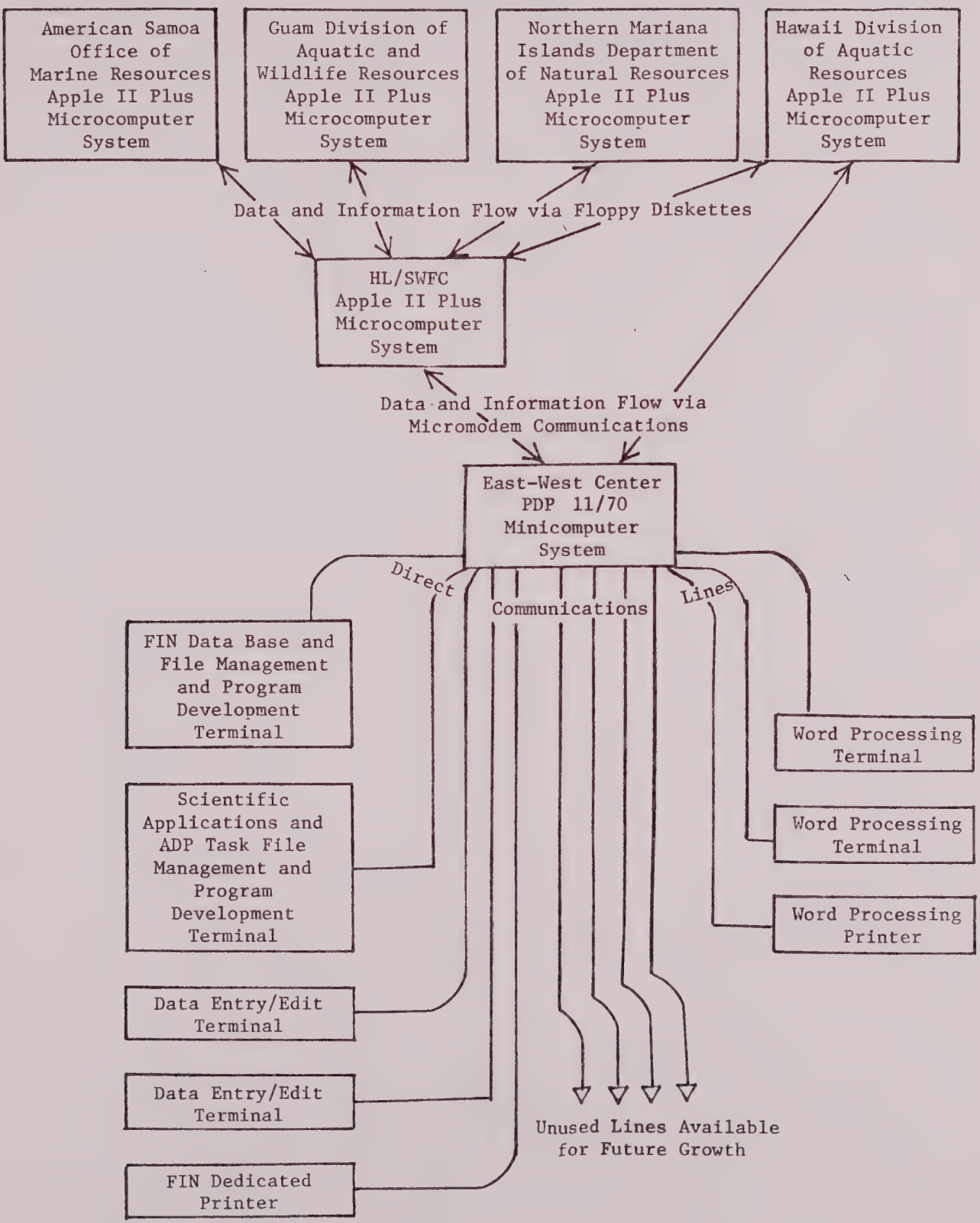
American Samoa Office of Marine Resources Apple II Plus Microcomputer System
Guam Division of Aquatic and Wildlife Resources Apple II Plus Microcomputer System
Northern Mariana Islands Department of Natural Resources Apple II Plus Microcomputer System
Hawaii Division of Aquatic Resources Apple II Plus Microcomputer System
Data and Information Flow via Floppy Diskettes
HL/SWFC Apple II Plus Microcomputer System
Data and Information Flow via Micromodem Communications
East-West Center PDP 11/70 Minicomputer System
Direct
Communications
Lines
FIN Data Base and File Management and Program Development Terminal
Scientific Applications and ADP Task File Management and Program Development Terminal
Data Entry/Edit Terminal
Data Entry/Edit Terminal
FIN Dedicated Printer
Word Processing Terminal
Word Processing Terminal
Word Processing Printer
Unused Lines Available for Future Growth

Figure 1.--The WPACFIN hardware configuration (see text footnote 2).

Southwest Fisheries Center Administrative Report H-82-9

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National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Southwest Fisheries Center
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FISHERY DATA NEEDS OF THE NATIONAL MARINE FISHERIES SERVICE IN THE HAWAIIAN ARCHIPELAGO

AUG 2 7 1982

National Marine Fisheries Service
2570 Dole Street
Honolulu, Hawaii

July 1982

I. INTRODUCTION

The implementation of the Magnuson Fishery Conservation and Management Act (MFCMA) of 1976, greatly increased the need for accurate and timely information on fisheries in the central and western Pacific. It became apparent that the existing fishery data collection procedures and data management practices were incapable of supplying the requisite data on a timely basis. In response to these needs, the State of Hawaii, Department of Land and Natural Resources, Division of Aquatic Resources (HDAR) (formerly Division of Fish and Game) and the Southwest Fisheries Center (SWFC), National Marine Fisheries Service (NMFS), entered into an agreement of understanding in May 1980 to implement a Western Pacific Fishery Information Network (WPACFIN). This agreement calls for a two-phase implementation of WPACFIN in Hawaii. The first, a design phase, involves an evaluation of the State's existing system for fishery statistics and the formulation of a plan to effect improvements. The second, an implementation phase, will involve improvements to be carried out by HDAR in cooperation with SWFC. These improvements may be at the data collection stage, the keypunching and computer storage stage, or the retrieval, processing, and report preparation stage.

This report was prepared by the Fishery Management Research Task, SWFC, for the use of HDAR in completing the first phase of the cooperative endeavor. It contains a statement of the fishery information needs of NMFS relative to national reporting requirements and to research activities associated with fishery management. The report does not include data needs pertaining to experimental resource research and surveys, or laboratory experiments on autecology.

II. NATIONAL REPORTING REQUIREMENTS

The Western Pacific Program Office (WPPO), Southwest Region, NMFS has a number of reporting requirements to incorporate Hawaii fishery data in the "Fisheries of the United States," "Processed Fishery Products," and other annual statistical reports. In addition, they have certain data collecting and reporting requirements associated with the MFCMA.

For these annual reports, WPPO must submit the following kinds of calendar-year data by the indicated dates:

1. Pounds of tuna (round weight basis) consumed in Hawaii fresh, frozen, and cured (15 January);

2. Landings of marine and estuarine catch (29 January) (Appendix 1, Figure 1);

3. Landings of freshwater catch (29 January) on Form 88-50 (Freshwater-Diadromous);

4. Data on disposition of the domestic catch, excluding waste from fish filleting and canning operations (29 January) (Appendix 1, Figures 2-4);

5. For canneries and large processing plants, the production of canned fishery products, fish fillets and steaks (raw only), and industrial products for each plant in Hawaii (19 February) (Appendix 1, Figure 5);

6. For processors, wholesalers, cold storage firms, and others, employment data and production of packaged, industrial, and cured fishery products, fresh and frozen, by species and product type in pounds and value (11 June) on Form 88-13 (Appendix 1, Figure 5).

In addition to these annual data reporting requirements, WPPO is required to collect enforcement data as given in regulations implemented pursuant to approved fishery management plans. Such data might pertain to gear, seasons, or area restrictions, licensing, minimum sizes, or allowable catch. The "Final Fishery Management Plan for the Precious Coral Fisheries of the Western Pacific Region" has been approved, but regulations have not yet been published. The "Preliminary Fishery Management Plan for Seamount Groundfish Fishery Resources (Pelagic Armorhead and Alfonsins)" and the "Final Preliminary Fishery Management Plan for Pacific Billfish, Oceanic Shark, Wahoo, and Mahimahi" have been approved, and regulations have been implemented (Appendices 2 and 3). The latter regulations call for the collection of catch and effort data from foreign fishers only. In addition, as soon as possible after 1 September, WPPO must report the domestic catch of billfishes (by species) and shark in the Hawaiian Archipelago. These data are used to determine the percent of the domestic "reserve" that is harvested and then whether to release the remainder of the "reserve" to the "total allowable level of foreign fishing." When other fishery management plans are approved, for example, on spiny lobsters and bottom fishes, additional data collecting and reporting requirements will come into effect.

III. RESEARCH ACTIVITIES

The SWFC is responsible for providing other elements of NMFS, the Department of Commerce, Department of State, and the Western Pacific Regional Fisheries Management Council (WPRFMC) with scientific advice relating to fisheries. Such advice encompasses determining the need for management (stock assessment and socio-economic evaluations); providing basic descriptions of fish stocks and fisheries; social and economic conditions; monitoring trends in the fisheries; and evaluating the effectiveness of management measures.

Whereas the SWFC does not have any administrative or legal deadlines for reporting data, time constraints are dictated by the need to provide timely reports containing current data to the users indicated above. Therefore, time constraints on the availability of data will be proposed in the material presented below.

Studies performed to provide the advice described above depend on the existence of accurate, current statistics. The specific data sets thus required are described below in subheadings for fisheries and market data needs. To reduce redundancy, fish species and associated fishing gears of importance to SWFC will be listed in the last subheading.

A. Fisheries Data Needs

1. Landings

Catch is usually defined as the number or weight of fish caught on a given date, whereas the definition for landings is the weight of fish actually retained and landed on a particular but commonly later date. The amount landed and its ex-vessel value, and the place and date landed comprise the essential elements required for monitoring any fishery. These data should be available within 3 months of the date of landing. Specifics are given below.

Landings (metric tons, pounds, or short tons), ex-vessel value:

by species or species group;

by fishing gear (e.g., tuna longline, pole and line, ika-shibi, trap);

by vessel type, including number of boats making the landings (e.g., both commercial and recreational domestic boats and foreign boats);

by trip, with monthly and annual summaries possible (sometimes the number of days absent or fished per trip are included);

by gross areas of capture, if possible (e.g., by 0-3, 3-12, and 12-200 nmi zones; or by HDAR statistical areas).

Possible sources of these data include the Hawaii Fish Dealer Report or landing slips, Hawaii Fish Catch Report, and recreational fishing surveys.

2. Vessel information

Those boats operating in each major species or gear-type fishery should be documented. Such information is essential for describing the fisheries and evaluating the economic impacts of proposed management strategies. In addition to classifying the vessels by fishery, the following information should be obtained:

length and gross tonnage,

type and horsepower of engine,

gear type and amount of gear carried,

carrying capacity of fishholds,

crew size (captain, fishing crew, plus others),

fuel usage,

operating costs,

moorage,

classification (commercial, subsistence, and recreational).

As part of a fishing vessel inventory project conducted in cooperation with WPRFMC, the SWFC is determining various vessel characteristics and classifying the vessels by fishery. The proposed questionnaire is presented in Appendix 3.

Some of these data are amenable for collection on routine vessel registration or documentation forms; hence, SWFC and HDAR should work cooperatively with the Hawaii Department of Transportation and the U.S. Coast Guard in augmenting their registration procedures.

3. Catch and fishing effort

These data are needed to assess the state of the resources and the fisheries, to estimate maximum sustainable yield and optimum yield, and to determine the need for management and formulate management options. Catch and fishing effort along with precise data on location of capture constitute what are commonly referred to as logbook data. The location data should be relatively precise, e.g., 1^{o} lat. x 1^{o} long. or small statistical areas. Because of the importance of fish aggregating devices and manmade rafts in fishery development, it may be desirable to provide for the recording of such information.

Preliminary estimates should be available 3 months after the date of capture and final figures within 6 months to provide timely quantitative assessements of the resources. If within-season regulations are implemented, availability of these data may be needed on a real-time basis.

Catch, as defined previously, is the total amount of fish taken by the fishing gear whether retained and landed or not. Catch can be reported in either number, especially for highly valued species such as large tunas, billfishes, and bottom fishes, or in weight (e.g., metric tons) for smaller, lesser valued species.

Fishing effort should be measured in terms relating to the mortality caused by the gear and be usable in socio-economic analyses also. The actual units of measurement employed vary considerably depending on species and fisheries, but generally involve the number of units of the gear employed and frequently the time the gear is deployed as well. Examples include the number of hooks or hook-days, the number of sets or set-days, the number of tows (or drags) or tow-hours, and number of traps or trap-days. Specific examples will be given below for several important fisheries. It is also important to describe the individual gear types because different sizes or configurations of traps, longline, trawls, etc., will have different fishing powers.

Skipjack tuna pole-and-line fishery.--The Aku Catch Report provides for reporting of catch in weight by species and fishing effort in numbers of fishing days (including zero catch days) and number of men fishing, all by HDAR statistical areas. These data seem sufficiently accurate for quantitative analyses if the data forms are filled in completely.

Closely associated with this fishery is that for baitfish, primarily nehu. Attempts to assess the state of the nehu stocks have met with limited success, and several reasons have been cited. With respect to catch, concern has been voiced about the bucket as a meassure of catch, but it is probably as good a measure as can be obtained. Although it does not relate to assessing nehu, the incompleteness and inconsistency in the records of quantity of bait used and bait mortality precludes their use in assessing the catch of tuna per bucket of bait and other measures of the value and effectiveness of the bait. With respect to fishing effort for bait, "fishing day" does not seem to be accurate enough for stock assessment purposes. Thus, the number of sets made should also be recorded, and data on the type and size of net used should be collected. Subareas within bays and harbors should perhaps be designated for use in the "Location Fished" field.

Tuna troll and other fisheries.--The Fish Catch Report can and should provide daily catch estimates by species, but the reports are frequently not completed in such detail. In addition, skipjack tuna, shark, and other species are often not reported because they are not always landed and sold. This problem results in underreporting of total catch.

Longline fishery for large tunas and billfishes.--The Flagline Catch Report provides for the reporting of catch in number and weight by species, but only on a trip basis. While these effort statistics are of some utility for simple economic considerations, they are not sufficient for stock assessment or in-depth economic evaluations because the number of fishing days per trip presumably varies seasonally and among boats in the fleet. It is often desirable and sometime necessary under the MFCMA to compare the efficiency of various domestic fleets or the domestic longline fleet with foreign fleets, but this cannot be done with the quality of the existing domestic data. Therefore, the number of days fished per trip should be recorded, and it would be highly desirable to also have the number of hooks recorded, which would then make the domestic statistics comparable to those recorded in most distant water, longline fisheries and allow direct comparisons of catch per unit effort statistics.

Ika-shibi and palu ahi fisheries for large tunas.--These fisheries are among the fastest growing and profitable in Hawaii. Significant amounts of billfishes are taken in addition to the target tuna species. Statistics for this fishery are reported as deep-sea handline on the Fish Catch Report; hence, it is difficult to separate tuna fishing from deep-sea fishing for bottom fish. If operational details of these tuna fisheries are to be documented, it is essential that a separate designation for this type of fishing be provided on the Fish Catch Report. Catch by species and by day may be sufficient for stock assessment purposes and detailed comparisons among fisheries or vessel types. If effort in days is determined to be an insufficiently accurate measure of mortality, then special projects may have to be designed to collect fishing effort in number of hook-hours or some comparable measure.

Bottom fish handline fishery.--Some Fish Catch Reports are submitted with number of fishing days recorded, but most only include catch by trip or even by month. The latter two levels of accuracy for fishing effort are not sufficient for stock assessment or detailed economic evaluations.

Fishing effort should at least be recorded in terms of the number of days fished. The number of lines or hooks per day would provide a better measure of effort, but such detailed statistics may be difficult to obtain.

Spiny lobster fishery.--For the commercial fishery, catch reports should consist of daily recordings of the number or weight of spiny lobsters caught and the number of traps fished per day as well as the precise area fished. For recreational fishers, it would probably be sufficient to report catch in numbers or weight by species and the total number of days fished per month. Again, daily recording of catch and the amount of gear used per day would be better, but difficult to obtain.

Precious coral fishery.--Catch in weight by species should be reported per tow or minimally by fishing day. Fishing effort should be as specific as possible, for example, the number of mop-hours per tow or less desirably the number of mop-tows, tows, or mops. Alternatively, a measure of the length of tows (for mops) or searches (for submersibles) plus the size of the mop or width searched by a submersible would provide a measure of the area swept or fished by the fishing gear.

4. Size composition

Size data in either length or weight are generally collected from a subsample of the landings to determine size composition of important species on a monthly or quarterly basis. Historical records of size composition can provide valuable early warning of significant changes in fish stocks or the fisheries. For example, changes in average size frequently indicate a decline in the abundance of older age groups in the stock or possibly a change in the targeting strategy of the fishery. Missing or poorly represented year-classes suggest possible problems with spawner-stock recruitment. Or, drastic changes in size composition may suggest the occurrence of different stocks in the fishery. In addition, such data may also be used to estimate total mortality (with estimates of catch per unit effort) and growth. The SWFC collects such data from skipjack tuna landings; however, size measurements of other important species, e.g., spiny lobsters, bottom fishes, small pelagic fishes, and reef fishes, are not now collected routinely by any agency. If minimum size regulations are implemented pursuant to implementation of the Spiny Lobster Fishery Management Plan, NMFS will have to establish a special sampling project.

5. Recreational fishing

The NMFS has recently established a marine recreational fishing policy that includes the determination of the recreational community, catch, and fishing effort. For the most part, the latter two pieces of information are not now currently available in Hawaii and could, probably, only be obtained by conducting special studies. However, catch, fishing effort, and other data on subsistence fishers who sell at least part of their catch, should be available from the State's Fish Catch Report. As for determining the recreational fishing community, several factors are involved. First, in the absence of a marine fishing licensing program, determining the number of persons by type of fishing activity can probably be best obtained by conducting surveys. Second, the number and type of

sport fishing clubs should be obtainable by conducting an enumeration study. Third, the determination of supporting industries involves the identification of suppliers of equipment, gear, repair services, fuel, etc. and would require special, detailed surveys.

B. Market Data Needs

1. Wholesale fish dealer

In addition to being a possible source for the basic landings data described above, data on the wholesale fish dealers have utility in management considerations. Information, by fish products, on the volume of sales, the value added in processing or rendering of services, as well as employment, can be used to make projections about the consequences of alternative management regimes. Such information can be obtained from a viable fish dealer reporting program or by special survey.

2. Fish processor

Again, information on this sector of the fish market structure is necessary if reasonably accurate projections are to be made of the likely consequences of management alternatives. The MFCMA requires that the domestic processing capacity be determined and utilized in determining the allocation of resources between domestic and foreign interests. To be most usable, the volume of sales by product type and form should be determined. These data can probably best be obtained by special surveys conducted every 3 to 5 years.

3. Support industries

The prediction of the impact of fishery policies on other segments of the economy is a topic often alluded to but seldom investigated. A start at such an investigation might involve obtaining employment and gross revenue data for industries providing repair and other services, supplies, gear, and equipment to fishermen, both commercial and recreational, and to wholesale fish dealers. Special studies could be conducted to obtain such information.

4. Cannery, transshipment, and import/export data

The cannery in Hawaii makes a major contribution to the local economy and provides a significant alternative market for skipjack tuna captured by the domestic pole-and-line fleet. Foreign and interstate imports of seafood play a major role in household and institutional consumption. Likewise, export of fish products from Hawaii is becoming an increasingly important business venture.

Collectively, information on cannery purchases, cannery pack, transshipment of tuna, and imports/exports of various fish products is essential to interpreting the market structure in Hawaii, assessing their interrelationships, and to understanding the impact of the fishing industry on the local economy.

The U.S. Customs Service records in detail foreign imports into Hawaii, and the Army Corps of Engineers records domestic shipments (by vessel only). Export data are generally unavailable, except for bulk transshipment of tuna. Information on the export of high-value fish and shellfish, such as yellowfin tuna and spiny lobster, is not available.

Although cannery and import data are currently available, new arrangements should be made to capture data on transshipments and on imports and exports to and from the U.S. mainland and foreign sites. Information on the latter two categories may be obtainable only through surveys. Data should be collected by species or in some cases by species groups and should include price and quantity on a transaction basis (daily or at least monthly). Data on product flow by carrier (e.g. by vessel) would also be useful.

C. Fish and Shellfish Species

Historically, SWFC has placed a great deal of emphasis on large pelagic species because of their development potential and their importance to the local Hawaiian fishing industry. Today, these species are still important because of domestic commercial and recreational fishing activities, U.S. processors' dependence on the resources, and foreign fishing activities in the U.S. Fishery Conservation Zone. Listed below are the key species and associated gear types.

Tunas

- Skipjack tuna or aku
- Yellowfin tuna or ahi
- Bigeye tuna or ahi
- Albacore or ahipalaha
- Kawakawa (primarily domestic)

Billfishes

- Blue marlin
- Striped marlin
- Swordfish
- Black marlin
- Shortbill spearfish
- Sailfish

Sharks

- Silky shark
- Whitetip shark
- Blue shark (primarily foreign)
- Thresher shark
- Tiger shark
- Hammerhead shark

Others

Mahimahi
Wahoo or ono

The species listed above are caught in the following fisheries:

Pole and line (domestic and foreign)
Troll (domestic commercial and recreational)
Tuna longline (domestic and foreign)
Ika-shibi (domestic commercial and recreational)
Palu ahi (domestic commercial and recreational)
Gill net (foreign)

Because of several recent developments, i.e., the SWFC's resource surveys in the Northwestern Hawaiian Islands, the initiation of a commercial fishery on the spiny lobster resource in that area, and management efforts on the spiny lobster by WPRFMC, SWFC has recently put considerable emphasis on the following shellfish species:

Spiny lobster

Red spiny lobster, Panulirus marginatus
Green spiny lobster, P. penicillatus

Slipper lobsters (two common species)

Crab

Kona crab

Shrimp

Penaeid shrimp, Penaeus marginatus
Caridean shrimps, Heterocarpus ensifer and H. laevigatus

The following gears are used to catch the shellfishes listed above:

Traps (primarily domestic commercial)
Nets (domestic commercial and recreational)
Spear (domestic recreational)
Trawls (domestic commercial)

Again following SWFC's resource surveys in the Northwestern Hawaiian Islands and the interest expressed by WPRFMC in managing the bottom fish stocks, SWFC has placed increasingly more effort on bottom fish or groundfish resources.

Bottom fishes or groundfishes

Alfonsin (primarily foreign)
Pelagic armorhead (primarily foreign)
Opakapaka
Lehi

Ehu
Gindai
Large jacks, crevally or ulua
Hapuupuu
Amberjack or kahala, Seriola dumerili
Onaga
Uku

The following gears are used to catch these species:

Handline (domestic commercial and recreational, and foreign)
Bottom longline (domestic commercial and recreational, and foreign)
Trap or pot (domestic)
Gill nets (domestic)

The SWFC has had an interest in nehu and other baitfish resources because of their importance in the skipjack tuna fishery in Hawaii. Now with the passage of the MFCMA, interest has expanded to include other small, neritic pelagic species inhabiting waters extending into the U.S. Fishery Conservation Zone.

Small pelagic fishes

Bigeye scad or akule
Mackerel scad or opelu, Decapterus pinnulatus
Red tailed mackerel scad, D. maruadsi
Pelagic nehu and other baitfish

These species are caught by the following fishing gears:

Handline (domestic)
Purse seine net (domestic)
Surround net (domestic)

Due to the MFCMA, precious coral is also of direct interest.

IV. CONCLUSION

The preceding pages outline the NMFS information needs for Hawaii's fisheries. Clearly, biological and economic analyses and management initiatives require timely and accurate data, but these requirements must be placed in the context of their cost to society. Thus, costs and benefits must be taken into consideration both by NMFS and HDAR in their design phase for implementing WPACFIN.

Appendix 1, Figure 1

NOAA FORM: 88-50
(MARINE (PACIFIC)

LANDINGS BY DISTANCE CAUGHT FROM SHORE: PACIFIC, HAWAII, AND WESTERN PACIFIC

YEAR (1-2) / STATE CODE (3-4) / REGION (5) / STATE NAME	SPECIES (USE PREPRINTED CODES ONLY)	SPECIES CODE (6-9)	DISTANCE FROM U.S. SHORES (EVERYTHING IN THOUSANDS AND NO DECIMALS, PLEASE)				ALL OTHER (INCLUDES CATCH WITHIN 200 NAUTICAL MILES OFF FOREIGN COASTS)		TOTAL	
			0 TO 3 MILES		3 TO 200 MILES					
			THOUSAND POUNDS (10-16)	THOUSAND DOLLARS (17-22)	THOUSAND POUNDS (23-29)	THOUSAND DOLLARS (30-35)	THOUSAND POUNDS (36-42)	THOUSAND DOLLARS (43-48)	THOUSAND POUNDS	THOUSAND DOLLARS
	ALFONSIN	0016								
	ANCHOVIES.	0060								
	ARMORHEAD.	0126								
	BONITO	0330								
	COD, PACIFIC, UNCL . . .	0822								
	CROAKER.	0926								
	EELPOUTS	2500								
	FLOUNDER, ARROWTOOTH . .	1250								
	FLOUNDER, FLATHEAD SOLE.	1272								
	FLOUNDER, ROCK SOLE. . .	1282								
	FLOUNDER, YELLOWFIN SOLE	1287								
	FLOUNDER, GREENLAND TURBOT	4679								
	FLOUNDER, PACIFIC, OTHER	1295								
	HAKE, PACIFIC.	1542								
	HALIBUT (ROUND WEIGHT) .	1589								
	HERRING, SEA	1676								
	JACK MACKEREL.	1820								
	LINGCOD.	2090								
	MACKEREL, ATKA	2116								
	MACKERFL, PACIFIC. . . .	2150								
	MARLIN	2180								
	MULLET (BLACK OR SILVER)	2347								
	OCEAN PERCH, PACIFIC . .	2410								
	POLLOCK, ALASKA (WALLEYE)	2692								

SPECIES NAMES ARE THOSE USED IN DIGEST. ALL WEIGHTS SHOWN ARE ROUND (LIVE) WEIGHTS, EXCEPT FOR WEIGHTS OF BIVALVE AND UNIVALVE MOLLUSKS, WHICH ARE MEAT WEIGHTS. WEIGHT OF SCALLOP MEATS IS WEIGHT OF SHELL-CLOSING MUSCLE.

Appendix 1, Figure 1.--Continued.

NOAA FORM: 88-50
MARINE PACIFIC)

YEAR (1-2)	SPECIES	SPECIES CODE (6-9)		DISTANCE FROM U.S. SHORES (EVERYTHING IN THOUSANDS AND NO DECIMALS, PLEASE)				ALL OTHER (INCLUDES CATCH WITHIN 200 NAUTICAL MILES OFF FOREIGN COASTS)		TOTAL	
				0 TO 3 MILES		3 TO 200 MILES					
STATE CODE (3-4)	(USE PREPRINTED CODES ONLY)			THOUSAND POUNDS (10-16)	THOUSAND DOLLARS (17-22)	THOUSAND POUNDS (23-29)	THOUSAND DOLLARS (30-35)	THOUSAND POUNDS (36-42)	THOUSAND DOLLARS (43-48)	THOUSAND POUNDS	THOUSAND DOLLARS
	ROCKFISHES, OTHER. . . .	2960									
REGION (5)	SABLEFISH.	3020									
	SAILFISH	3026									
STATE NAME	SCULPINS	3260									
	SALMON, CHINOOK OR KING.	3080									
	SALMON, CHUM OR KETA . .	3081									
	SALMON, PINK	3082									
	SALMON, RED OR SOCKEYE .	3083									
	SALMON, SILVER OR COHO..	3084									
	SPEARFISH.	4000									
	STEELHEAD TROUT.	4150									
	SEA BASS, BLACK.	3361									
	SEA BASS, WHITE.	3370									
	SHAD, AMERICAN	3474									
	SHARK, DOGFISH (GRAYFISH)	3503									
	SHARKS, OTHER.	3508									
	SKATES..	3650									
	SNAPPER, RED	3764									
	SNAPPER, OTHER	3768									
	STRIPED BASS	4180									
	SWORDFISH.	4320									
	TUNA, ALBACORE	4651									
	TUNA, BIGEYE	4657									

SPECIES NAMES ARE THOSE USED IN DIGEST. ALL WEIGHTS SHOWN ARE ROUND (LIVE) WEIGHTS, EXCEPT FOR WEIGHTS OF BIVALVE AND UNIVALVE MOLLUSKS, WHICH ARE MEAT WEIGHTS. WEIGHT OF SCALLOP MEATS IS WEIGHT OF SHELL-CLOSING MUSCLE.

Appendix 1, Figure 1.--Continued.

NOAA FORM: 88-50
MARINE (PACIFIC)

PAGE PAGE 3 OF 4

LANDINGS BY DISTANCE CAUGHT FROM SHORE: PACIFIC, HAWAII, AND WESTERN PACIFIC

YEAR (1-2) / STATE CODE (3-4) / REGION (5) / STATE NAME	SPECIES (USE PREPRINTED CODES ONLY)	SPECIES CODE (6-9)	DISTANCE FROM U.S. SHORES (EVERYTHING IN THOUSANDS AND NO DECIMALS, PLEASE) 0 TO 3 MILES THOUSAND POUNDS (10-16)	0 TO 3 MILES THOUSAND DOLLARS (17-22)	3 TO 200 MILES THOUSAND POUNDS (23-29)	3 TO 200 MILES THOUSAND DOLLARS (30-35)	ALL OTHER (INCLUDES CATCH WITHIN 200 NAUTICAL MILES OFF FOREIGN COASTS) THOUSAND POUNDS (36-42)	ALL OTHER (INCLUDES CATCH WITHIN 200 NAUTICAL MILES OFF FOREIGN COASTS) THOUSAND DOLLARS (43-48)	TOTAL THOUSAND POUNDS	TOTAL THOUSAND DOLLARS
	TUNA, BLUEFIN.	4652								
	TUNA, LITTLE.	4653								
	TUNA, SKIPJACK.	4654								
	TUNA, YELLOWFIN	4655								
	TUNA, UNCLASSIFIED. . .	4656								
	FISH, MARINE, OTHER . .	5261								
	FISH, TOTAL									
	ABALONE	7390								
	CLAM, HARD (MEAT) . . .	7480								
	CLAM, SOFT (MEAT) . . .	7630								
	CLAM, OTHER (MEAT)... .	7720								
	CRAB, DUNGENESS	7060								
	CRAB, KING.	7090								
	CRAB, SNOW, OPILIO. . .	7183								
	CRAB, SNOW, BAIRDI. . .	7184								
	CRAB, OTHER	7190								
	LOBSTER, SPINY.	7300								
	MUSSELS, SEA (MEAT) . .	7810								
	OYSTER MEAT (ALL SPECIES)	7890								
	SCALLOP, SEA (MEAT) . .	8009								
	SHRIMP (HEADS-ON) . . .	7380								
	SNAIL (CONCH) (MEAT). .	7750								
	SQUID	8030								
	SEA URCHIN.	8050								

SPECIES NAMES ARE THOSE USED IN DIGEST. ALL WEIGHTS SHOWN ARE ROUND (LIVE) WEIGHTS, EXCEPT FOR WEIGHTS OF BIVALVE AND UNIVALVE MOLLUSKS, WHICH ARE MEAT WEIGHTS. WEIGHT OF SCALLOP MEATS IS WEIGHT OF SHELL-CLOSING MUSCLE.

Appendix 1, Figure 1.--Continued.

NOAA FORM: 88-50
MARINE (PACIFIC)

LANDINGS BY DISTANCE CAUGHT FROM SHORE: PACIFIC, HAWAII, AND WESTERN PACIFIC

PAGE 4 OF 4

YEAR (1-2) / STATE CODE (3-4) / REGION (5) / STATE NAME	SPECIES (USE PREPRINTED CODES ONLY)	SPECIES CODE (6-9)	DISTANCE FROM U.S. SHORES (EVERYTHING IN THOUSANDS AND NO DECIMALS, PLEASE)				ALL OTHER (INCLUDES CATCH WITHIN 200 NAUTICAL MILES OFF FOREIGN COASTS)		TOTAL	
			0 TO 3 MILES		3 TO 200 MILES					
			THOUSAND POUNDS (10-16)	THOUSAND DOLLARS (17-22)	THOUSAND POUNDS (23-29)	THOUSAND DOLLARS (30-35)	THOUSAND POUNDS (36-42)	THOUSAND DOLLARS (43-48)	THOUSAND POUNDS	THOUSAND DOLLARS
	CORALS	8160								
	SHELLFISH, OTHER	9990								
	SHELLFISH, TOTAL									
	GRAND TOTAL									

SPECIES NAMES ARE THOSE USED IN DIGEST. ALL WEIGHTS SHOWN ARE ROUND (LIVE) WEIGHTS, EXCEPT FOR WEIGHTS OF BIVALVE AND UNIVALVE MOLLUSKS, WHICH ARE MEAT WEIGHTS. WEIGHT OF SCALLOP MEATS IS WEIGHT OF SHELL-CLOSING MUSCLE.

Appendix 1, Figure 2.

NOAA FORM 88-51 (11-73)

U. S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

REGION *(if appropriate)*

YEAR

DISPOSITION OF DOMESTIC CATCH OF FISH AND SHELLFISH BY MONTHS

Submit by last day in February (preliminary) and by November 1st. (final). Indicate region, if appropriate, East & West Coast of Florida will be listed as individual States.

MONTH	STATE *(Please enter amount of catch in thousand pounds.)*					
JANUARY						
FOOD						
INDUSTRIAL						
FEBRUARY						
FOOD						
INDUSTRIAL						
MARCH						
FOOD						
INDUSTRIAL						
APRIL						
FOOD						
INDUSTRIAL						
MAY						
FOOD						
INDUSTRIAL						
JUNE						
FOOD						
INDUSTRIAL						
JULY						
FOOD						
INDUSTRIAL						
AUGUST						
FOOD						
INDUSTRIAL						
SEPTEMBER						
FOOD						
INDUSTRIAL						
OCTOBER						
FOOD						
INDUSTRIAL						
NOVEMBER						
FOOD						
INDUSTRIAL						
DECEMBER						
FOOD						
INDUSTRIAL						
TOTAL						
FOOD						
INDUSTRIAL						
GRAND TOTAL						

Appendix 1, Figure 3.

NOAA FORM 88-52
(11-73)

U. S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

REGION*

YEAR

DOMESTIC CATCH OF FISH AND SHELLFISH AND THEIR SPECIFIC USE

USE OF FISH AND SHELLFISH**

Please submit by the last day in February (preliminary) and by November 1st. (final).
**Indicate Region (New England, Middle Atlantic, etc.) or State, if appropriate. East and West Florida are separate States.*
***Indicate Animal food (fresh or frozen); Bait (fresh or frozen); Canned pet food; Reduction; or Other industrial purposes. NOTE: Include a footnote or separate table for imported fish used for the purpose indicated.*

SPECIES	STATE *(Enter all data in thousand pounds)*					

Appendix 1, Figure 4.

NOAA FORM 88-54
(11-73)

U. S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

REGION*

YEAR

DISPOSITION SUMMARY OF THE U. S. COMMERCIAL CATCH FOR FOOD AND INDUSTRIAL PURPOSES

Please submit by last day in February (preliminary) and by November 1st (final).
*Indicate appropriate Region (New England, Middle Atlantic, etc.) or State only, if applicable. East and West coasts of Florida are listed as separate States.
** Estimated (Indicate all data that are strictly estimates with "**").
NOTE: Poundage represents round weight for all species, except bivalve and univalve mollusks which are reported in weight of meats. Value represents the price paid to fishermen. Whole items are included as the weight and value of the products processed from these species.

ITEM	STATE											
	POUNDS	VALUE	POUNDS	VALUE	POUNDS	VALUE	POUNDS	VALUE	POUNDS	VALUE	POUNDS	VALUE
CATCH	(Enter in thousands only)											
State Landings Bull.												
Add. State Landings												
TOTAL CATCH												
DISPOSITION	(Enter in thousands only)											
Human food, total												
INDUSTRIAL USES	(Enter in thousands only)											
Animal food (fresh and frozen)												
Bait (fresh and frozen)												
Canned pet food												
Reduction												
Other												
TOTAL Industrial Purposes												

REMARKS

Appendix 1, Figure 5.

"This report is authorized by law, 16 U.S.C. 1854(e). While you are not required to respond, your cooperation is needed to make the results of this survey comprehensive, accurate and timely."

FORM APPROVED O.M.B. NO. 41-R-2597
EXPIRES: DECEMBER 1982

YEAR		COL. 1
REGION		2
STATE		3–4
PLANT NO.		5–9
COUNTY		COL. 10–16

NOAA FORM 88-13 (10-78)

U. S. DEPARTMENT OF COMMERCE
NOAA – NMFS

FISHERY PRODUCTS REPORT:
U.S. PROCESSORS AND WHOLESALERS, ANNUAL
(Individual Reports are Confidential and only Summary Totals are Published)

ARE YOU A:
- PROCESSOR
- WHOLESALER (Does Not Process)
- COLD STORAGE
- OTHER:

REPORT PREPARED BY

WHOLESALE FISH ITEMS HANDLED BUT NOT PROCESSED

SPECIES OR ITEM	COL. 18–19	COL. 20–22

EMPLOYMENT DATA – TO BE COMPLETED BY ALL FIRMS OR PLANTS

NOTE: Include only the employees handling fishery products. If employees handle all products at plant, prorate the number based on the time spent in handling fishery products. LIST BY MONTH THE NUMBER OF EMPLOYEES WORKING DURING THE PAYROLL PERIOD THAT INCLUDED THE 12TH OF THE MONTH.

JAN.	COL. 32–37	FEB	COL. 38–43	MAR.	COL. 44–49	APR.	COL. 50–55	MAY	COL. 56–61	JUNE	COL. 62–67
JULY	68–73	AUG.	74–79	SEPT.	80–5	OCT.	6–11	NOV.	12–17	DEC.	18–23

PRODUCTION DATA – TO BE COMPLETED ONLY BY PROCESSORS

PRODUCTION OF PACKAGED FISHERY PRODUCTS **Value should be based on selling price at plant*

SPECIES AND PRODUCTS *(Fillets, Steaks, Fishcakes, etc.)*	CODE	FRESH			FROZEN		
		PRODUCT CODE	POUNDS *(Processed Weight)*	VALUE FOB PLANT*	PRODUCT CODE	POUNDS *(Processed Weight)*	VALUE FOB PLANT*
	COL. 12–16	COL. 17–22	COL. 42–49	COL. 50–57	COL. 17–22	COL. 42–49	COL. 50–57
		1			2		
		1			2		
		1			2		
		1			2		
		1			2		
		1			2		
		1			2		
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		1			2		
		1			2		
		1			2		
		1			2		
		1			2		
		1			2		

PRODUCTION OF INDUSTRIAL FISHERY PRODUCTS

SPECIES AND PRODUCTS *(Meal, Oil, Solubles, Animal food, etc.)*	CODE	PRODUCT CODE	UNIT OF WEIGHT *(Pounds, Tons, Kilos, etc.)*	QUANTITY *(Processed Weight)*	VALUE FOB PLANT*
	COL. 12–16	COL. 17–22	COL. 52–53	COL. 42–49	COL. 50–57
		3			
		3			
		3			
		3			
		3			
		3			
		3			
		3			
		3			
		3			
		3			
		3			
		3			
		3			
		3			

Appendix 1, Figure 5.--Continued.

PRODUCTION OF CANNED FISHERY PRODUCTS — CC 80

SPECIES AND PRODUCTS	CODE	PRODUCT CODE	CAN SIZE	OZ PER CAN	CANS PER CASE	NO. OF CASES	VALUE FOB PLANT*
	COL 14–16	COL 17–22	COL 23–31	COL 34–38	COL 39–41	COL 42–49	COL 50–57
		3					
		3					
		3				

Appendix 2.--Regulations for "Preliminary Fishery Management Plan for Seamount Groundfish Fishery Resources (Pelagic Armorhead and Alfonsins)." (From Code of Federal Regulations. 50 Wildlife and Fisheries, Part 200 to end. Off. Fed. Reg., U.S. Gov. Print. Off., Wash., D.C., p. 478-480, 1980.)

Subpart F—Western Pacific Ocean

§ 611.80 Seamount groundfish fishery.

(a) *Purpose.* This subpart regulates all foreign fishing for pelagic armorheads and alfonsins conducted under a Governing International Fishery Agreement in the fishery conservation zone of the western Pacific Ocean.

(b) *Authorized fishery*—(1) *Allocations.* Foreign vessels may engage in fishing only in accordance with applicable national allocations.

(2) *TALFF.* The TALFFs for the seamount groundfish fisheries are set forth in Appendix 1 to § 611.20.

(3) *Species definitions.* The category "other groundfish" used in TALFFs and in allocations includes all species of finfish caught incidental to directed fishing for pelagic armorheads and alfonsins except billfish, oceanic sharks, wahoo, and mahimahi, and other fish caught pursuant to § 611.81.

(4) *Open Season.* Foreign fishing authorized under this subpart may begin at 0800 G.m.t. on May 1 and will terminate not later than 0800 G.m.t. on October 1. This fishery may also be closed in accordance with § 611.15.

(c) *Prohibited species.* All Continental Shelf fishery resources, and all other species of fish except for alfonsins, armorheads and other groundfish, are prohibited species and shall be treated in accordance with § 611.13.

(d) *Open area.* Foreign vessels may engage in fishing for pelagic armorheads, alfonsins, and other groundfish only in those portions of the fishery conservation zone west of the 180° meridian and north of 28° N. latitude.

(e) *Gear restrictions.* No gear other than trawl or bottom longline gear may be used.

(f) *Collection, maintenance and, reporting of data.* In addition to the requirements of § 611.9, each foreign nation or foreign fishing vessel shall collect, maintain, or report on a timely basis, accurate data relating to fishing operations as specified in this section. All submissions required by this section shall be sent to the Regional Director, Southwest Region, National Marine Fisheries Service, 300 South Ferry Street, Terminal Island, California 90731 or, in the case of logbook data, hand delivered to the National Marine Fisheries Service observer on board the vessel upon his request. The following logs and reports are required:

(1) *Fishing log.* (i) Each fishing vessel which conducts trawling operations shall maintain and submit a fishing log which contains data for each haul as follows:

(A) Vessel name and permit number;

(B) Date;

(C) Codend mesh size to the nearest millimeter;

(D) Length of the footrope to the nearest tenth of a meter (0.1 m.) and average distance between footrope and headrope to the nearest tenth of a meter (0.1 m.);

(E) Time at the beginning of the haul and the total duration of the haul to the nearest five (5) minutes;

(F) Location at the midpoint of each haul to the nearest tenth (0.1) minute of latitude and longitude;

(G) Average depth of the seabottom to the nearest meter;

(H) Average fishing depth of the footrope to the nearest meter;

(I) Average fishing speed of the vessel (towing speed) to the nearest tenth of a knot (0.1 kt);

(J) Catch, by individual species, to the nearest tenth of a metric ton (0.1 m.t.); and

(K) Approximate weight (kilograms, by genus, of the incidental catch of the corals designated in § 611.2(h) of this part.

(ii) Each fishing vessel which conducts longlining operations shall maintain and submit a fishing log which contains data for each fishing day as follows:

(A) Vessel name and permit number;

(B) Date;

(C) Midday location of fishing, to the nearest tenth (0.1) minute of latitude and longitude;

(D) Average depth of hooks set, in meters;

(E) Number of hooks set and average soak time;

(F) Number of fish caught, by species, for pelagic armorhead, alfonsin, and other groundfish species.

(iii) If the fishing log is not delivered to a National Marine Fisheries Service observer on board the vessel, it shall be mailed to the Regional Director not later than 30 days following completion of fishing.

(2) *Annual report.* Each nation whose vessels engage in the seamount groundfish fishery shall submit by February 28 of the following year, annual catch and effort statistics as follows:

(i) Catch in metric tons by gear type by month by area to the nearest one-half degree (0.5°) latitude and by one degree (1°) longitude, by the following species groupings; pelagic armorhead, alfonsin, other groundfish;

(ii) Catch in kilograms of corals taken incidental to fishing operations by month by area to the nearest one-tenth degree (0.1°) latitude and longitude by the following species groupings: pink coral, gold coral, bamboo coral, other corals; and

(iii) Effort, in hours trawled or average number of hooks soaked per 24-hour period, by month by area to the nearest one-half degree (0.5°) latitude and one degree (1°) longitude.

[43 FR 59293, Dec. 19, 1978, as amended at 44 FR 17184, Mar. 21, 1979; 44 FR 76541, Dec. 27, 1979; 45 FR 14587, Mar. 6, 1980]

Appendix 3.--Regulations for "Final Preliminary Fishery Management Plan for Pacific Billfish, Oceanic Shark, Wahoo, and Mahimahi."

DEPARTMENT OF COMMERCE

National Oceanic and Atmospheric Administration

50 CFR Part 611

Foreign Fishing for Billfish, Oceanic Sharks, Wahoo, and Mahimahi in the Pacific Ocean; Final Regulations

AGENCY: National Oceanic and Atmospheric Administration/ Commerce.

ACTION: Final regulations.

SUMMARY: These final regulations implement the Preliminary Fishery Management Plan for Billfish, Oceanic Sharks, Wahoo and Mahimahi in the Pacific Ocean (PMP). These regulations govern vessels of foreign nations engaged in longline fishing which results in the catching of billfish, oceanic sharks, wahoo or mahimahi in the fishery conservation zone (FCZ) of the Pacific Ocean (excluding the FCZ seaward of Alaska).

EFFECTIVE DATE: April 1, 1980, except that 50 CFR 611.3, which specifies permit requirements for foreign vessels, shall not be effective until May 1, 1980.

FOR FURTHER INFORMATION AND COPIES OF THE REGULATORY ANALYSIS CONTACT: Mr Gerald V. Howard, Regional Director, Southwest Region, National Marine Fisheries Service, 300 South Ferry Street, Terminal Island, CA 90731, telephone 213–548–2575; or Mr. Doyle E. Gates, Western Pacific Program Office, Southwest Region, National Marine Fisheries Service, Southwest Fisheries Center, P.O. Box 3830, Honolulu, Hawaii 96812, telephone 808–946–2181.

SUPPLEMENTARY INFORMATION:

a. Background

These regulations implement the Preliminary Fishery Management Plan for Billfish, Oceanic Sharks, Wahoo and Mahimahi in the Pacific Ocean, as amended (PMP). The PMP applies to foreign longline fishing, pursuant to a Governing International Fishery Agreement, which results, or can reasonably be expected to result, in the catching of billfish, oceanic sharks, wahoo and mahimahi in the FCZ of the Pacific Ocean (excluding the FCZ seaward of Alaska). The PMP was prepared under the authority of Section 201(h) of the Fishery Conservation and Management Act of 1976, as amended (16 U.S.C. 1801 *et seq.*, "the Act").

A foreign longline fishery for tuna has been conducted in the Pacific Ocean for many years. Although the primary target species is tuna, incidental catches of billfish, sharks, wahoo and mahimahi are unavoidable in this fishery. The Act provides for the management of all "fish." "Highly migratory species," as defined in 50 CFR 611.2(x), are specifically excluded from the definition of "fish." Other pelagic species such as billfish, oceanic sharks, wahoo and mahimahi are not considered highly migratory under the Act. The purpose of the PMP, as amended, is to establish a conservation and management plan for these pelagic species.

A final environmental impact statement (EIS) was filed with the Environmental Protection Agency on June 2, 1978. Proposed implementing regulations and the approved PMP were published on July 21, 1978 for public comment (43 FR 31374). Several of the comments received stated that further recognition should be given to the special social and economic impacts of the plan on various areas of the Pacific, particularly American Samoa. The comments also reflected some misunderstanding about which actions were optional and which actions were mandatory for foreign vessels to comply with the implementing regulations. In response to the comments, the proposed regulations were withdrawn on September 14, 1978 (43 FR 41062). Amendments to the PMP were developed and a draft supplemental EIS/PMP was filed with the Environmental Protection Agency on March 15, 1979. The amendments and proposed regulations were published on June 15, 1979 (44 FR 34607), and the public was invited to comment on the amendments, regulations and draft regulatory analysis until August 12 1979. Only two sets of comments were received on the proposed regulations.

These are addressed in Section (d) below.

The regulations will be implemented April 1, 1980. In the time between the publication of the regulations and their effective date, the U.S. Coast Guard and the National Marine Fisheries Service (NMFS) will inform the affected nations of the regulations. To allow adequate time for Regional Fishery Management Council review and approval of permit requests and for installation of these permits aboard foreign vessels, § 611.3 will not apply until May 1, 1980.

b. The PMP Amendments and Final Regulations

The PMP amendments and implementing regulations incorporate five major changes to the PMP as originally approved and published:

1. The area covered by the PMP has been divided into five regulatory areas. The optimum yield (OY), expected domestic harvest, and total allowable level of foreign fishing (TALFF) for each species has been specified for each of these five regulatory areas: mainland West Coast; Hawaii and Midway Island; American Samoa; Guam and the Commonwealth of the Northern Mariana Islands; and U.S. possessions. The major purposes of this change are (a) to recognize the varying social, economic, and recreational interests in these areas; and (b) to achieve a closer adherence to a major objective of the PMP, which is maintenance of the *status quo* with respect to total catches for the species concerned.

Division of the FCZ into five regulatory areas provides a better basis for determining appropriate restrictions on the foreign retention of billfish, oceanic sharks and associated species based on historical harvest in each area. Under the original PMP, foreign vessels could have harvested the entire TALFF for a particular species in one area covered by the PMP, thus upsetting the historical balance of catch by areas and, depending upon where the fish are harvested, adversely affecting the economic, recreational, or social interests of other areas covered by the PMP.

2. The fishery has been expanded to include wahoo and mahimahi. These species are often taken in conjunction with billfish and oceanic sharks, by the same vessels and gear. They have been included in order that the PMP will address all of the species which are important to domestic vessels and are harvested by tuna longline gear in the FCZ.

3. The management unit includes the Northern Mariana Islands, to which the Act is now applicable.

4. For some species, in certain areas, amounts of fish have been set aside in "reserves" to accomodate the possibility that domestic catches will exceed the estimated levels. The amount of fish which will be harvested by domestic fishermen is dependent in part upon wide fluctuations in availability. This factor, combined with uncertainty about the extent to which U.S. vessels, having the capacity, will actually harvest these species, has led to establishment of reserve amounts to help assure that the OY's will not be exceeded if the amounts of U.S. harvests are underestimated. A reserve for sharks has been established in the Hawaii and Midway Islands area because of indications that a U.S. shark fishery may be developing there.

5. The reporting and inspection requirements have been modified and clarified to avoid misunderstandings reflected in the comments received on the original PMP and the proposed regulations. Reporting requirements have been minimized; the number of ports where the holds of fishing vessels may be sealed has been increased; and provision has been made for the Administrator, Western Pacific Program Office, National Marine Fisheries Service, to authorize alternatives to sealing the holds in special circumstances. Use of logbooks combined with radio reports is one of the alternatives which may be considered in situations where sealing the holds may be impracticable (section d.3. of this preamble).

c. Editorial and Data Changes in the PMP and Amendments

Because of new data developed and typographical errors in the original PMP and amendments, several changes to the original PMP published in the Federal Register on July 21, 1978 (43 FR 31374) and in the amendments published on June 15, 1979, (44 FR 34607) are necessary. These changes are listed in this document immediately following the preamble and should be noted in all copies of the original PMP and the amendments to the PMP.

d. Comments on the Proposed Regulations

Only two sets of comments on the proposed regulations were received. A summary of these comments and responses to the comments follows:

1. *Definition of Fishing.* The Government of Japan proposed that Japanese vessels should not be subject to the regulations since they do not make use of these non-tuna species. This proposal cannot be accepted. The Act defines "fishing" to mean: (a) The catching, taking or harvesting of fish; (b) the attempted catching, taking or harvesting of fish; (c) any other activity which can reasonably be expected to result in the catching, taking, or harvesting of fish * * *" (Section 3(10)). Longline fishing for tuna unavoidably results in the catching of billfish and other non-tuna species; therefore, it is "fishing" as defined in the Act and is covered by these regulations. All Japanese and other foreign longline vessels fishing in the FCZ are subject to these regulations whether or not billfish, oceanic sharks, and other non-tuna species are intended to be retained.

2. *Determination of OY and TALFF.* One commentator indicated that the data used to derive OY and TALFF are skimpy and misleading. He noted also that, as foreign island areas declare their own 200-mile zones, the longliners based in American Samoa may spend more of their time fishing in the waters around American Samoa. The PMP, in his view, does not address this concern. In response, we note that the PMP contains the best and most recent information available on domestic and foreign catches in the FCZ around American Samoa, including a recently completed analysis of foreign catch and effort in the 1971–75 period. We have received no documentation indicating that our information is inaccurate or that American Samoa-based longliners desire or intend to increase their fishing activity in the FCZ. Further, the PMP would limit only the amounts of billfish, oceanic sharks, wahoo, and mahimahi taken and retained in the FCZ. If conditions in the fishery in 1980 are markedly different from those envisioned, we would consider amending the PMP and would work with the Regional Fishery Management Councils to insure full consideration of these new conditions in future fishery management plans' conservation and management measures.

3. *Hold Sealing.* The proposed regulations (§ 611.61(c)(3)) provide that foreign vessels could, but would not be required to, request inspection and sealing of holds to verify the quantity of billfish, oceanic sharks, and other non-tuna species caught outside the FCZ prior to engaging in fishing in the FCZ. This was intended as a means of rebutting the presumption of § 611.13 of the Foreign Fishing Regulations that any prohibited species found on board a foreign fishing vessel were caught and retained in violation of the regulations. A specific alternative to hold sealing which involved segregating prohibited species caught outside the FCZ by covering them with a net, and using

radio reports and log entries to document the catch outside the FCZ, was suggested by the Government of Japan. The proposal is among the alternatives which may be used by NMFS. The proposed regulations provide the necessary flexibility for the Administrator of the Western Pacific Program Office to use "other reasonable means" if warranted by special circumstances, as alternatives to hold sealing. Hold inspection and sealing will not be required of all foreign fishing vessels. No change in the regulations is necessary to respond to the comment.

4. *Radio Reporting.* The Government of Japan noted that some smaller vessels do not have radios, do not have English-speaking radio operators, or do not have radio operators licensed to handle public international communications. Rather than using the reporting requirements of the regulations, Japan proposed that vessels submit to U.S. authorities their operating plans for ten day periods at three-month intervals; or that certain vessels only be required to report when they intend to begin and cease fishing in the FCZ. They further requested that transmissions be allowed to be made through a third party, e.g., the Japanese mainland. The vessel reporting requirements have been amended to allow foreign vessels flexibility in reporting fishing activities within the FCZ in lieu of the § 611.4 requirements of this part. The regulations do not preclude submission of the required vessel reports through a third party, including those on the Japanese mainland.

5. *Observers.* The Government of Japan proposed, in effect, that observers be placed on board foreign vessels and returned to shore at the convenience of the vessel. This proposal would be an exception to the general NMFS policy to retain the discretion to determine where and when observers will be placed on foreign vessels. The decision is based on NMFS data needs, not foreign vessels' convenience or schedules. However, NMFS and Coast Guard resources and the burden imposed on foreign vessels are considered in determining when boarding is to occur. No persuasive reasons have been advanced to change this policy and the proposal will not be adopted.

The comment was also made that where no species regulated under the Act are caught, there is no authority to place observers. We note once again that catching billfish, sharks, mahimahi, and wahoo is unavoidable when longlining for tuna. Therefore, tuna longline boats are "fishing" under the Act, and placement of observers is an appropriate management measure.

6. *Statistical Reports.* Japanese representatives submitted a form with the request that it be used for the quarterly statistical report. We appreciate the submission of the form. It is under consideration as the form to be provided for the reports required by § 611.81(e)(3).

7. *Handling of Prohibited Species.* The Government of Japan proposed that the regulations be modified so that release, when required, could be effected under the general provisions of § 611.13, which allows a vessel to bring the fish on board and then discard the prohibited species. It is contended that in-water release should be required only for fish that are alive. Also, it is contended that release of sharks by cutting the line is dangerous to crew members.

The proposed regulations provided that prohibited billfish and oceanic sharks must be released "by cutting the line * * * without removing the fish from the water." This is intended to achieve the highest possible rate of survival of billfish and oceanic sharks when they are released. It is difficult to determine from visual observation if a billfish in the water is dead or alive. The chance of survival of a fish which is inactive but alive is clearly reduced by removal from the water.

In addition, it appears that bringing a live oceanic shark on board for subsequent release may present as great a hazard to the crew as cutting the line or leader. We note also that the survival of a shark would seem less likely since a gaff probably would have to be used to bring the shark on board the vessel. No new evidence or data are presented to support the position of the Government of Japan. Therefore, the release provisions have not been changed.

8. *Administrative Costs.* One commentator indicated that the cost of administering the program would be excessive to the taxpayer. The commentator apparently believed it is the intent of NMFS to place an observer aboard every foreign longline vessel operating in the FCZ. This is not our intent. We are aware of the practical difficulties associated with any fishery enforcement efforts in such distant areas as American Samoa, Guam, and the Northern Mariana Islands. NMFS and the U.S. Coast Guard will administer the PMP to the best of their ability given available resources. Incremental costs of administering the PMP will be minimal.

9. *Exemption for American Samoa-Based Vessels.* One commentator proposed that vessels in American Samoa be exempted from the regulations on the grounds that the foreign vessels there should be considered as a domestic fleet. We recognize that U.S. canneries are dependent on the foreign vessels, but under the Act and associated regulations, these vessels are "foreign fishing vessels" and will be subject to the PMP and its implementing regulations.

e. Changes from Proposed Regulations

The following changes have been made for this final rulemaking:

1. Section 611.81(a)(2), *Species definitions,* has been expanded to include "billfish" and "wahoo."

2. Section 611.81(d) has been significantly amended. The numerous small vessels engaging in this fishery have limited communication capability. Accordingly, the vessel reporting requirements have been revised so they can be met by all vessels participating in the fishery. Each vessel must submit its scheduled fishing activities in each regulatory area at least a week before it begins fishing. Neither minor deviations from this schedule nor temporary departures from the FCZ need to be reported. Major changes must be reported as soon as practicable. If these relaxed vessel reporting requirements are found, in practice, to fail to supply sufficient and timely data for effective management of the fish stocks, more stringent reporting requirements will be implemented in the future.

3. Section 611.81(e) has been amended to clarify the catch reporting requirements to which foreign vessels are subject.

4. The table specifying reserves and TALFF's has been corrected to cover the remaining portion of the 1980 calendar year.

f. The Implementing Regulations

These regulations apply only to foreign longline vessels "fishing" (as defined in § 611.2(r) of this part) in the FCZ in the Pacific Ocean, excluding the portion of the FCZ seaward of Alaska. Longline vessels, merely in transit through the FCZ (but not fishing) would not be subject to the requirements of this section or the other provisions of Part 611.

Any foreign vessel desiring to engage in longline fishing in the FCZ of the Pacific Ocean must possess a permit for that purpose, whether or not the billfish, oceanic sharks, wahoo, or mahimahi caught will be retained. Permits are required even though the foreign longline vessel is rigged and fishes primarily for the purpose of taking highly migratory species over which the United States does not exercise

exclusive fishery managment authority. Any foreign nation whose vessels wish to retain billfish, oceanic sharks, wahoo, or mahimahi caught in the FCZ also must hold a national allocation from the total allowable level of foreign fishing (TALFF) for the applicable species and fishing area.

The PMP establishes OY's, expected domestic harvests, reserves, and TALFF's for billfish, oceanic sharks, wahoo, and mahimahi, as shown in Table 6 of the PMP, as amended.

The TALFF's are established on an annual basis. The proposed regulations published on June 15, 1979, included TALFF's and reserves for 1979. These have been deleted from the regulations, and TALFF's and reserves for 1980 have been subsituted, because the regulations will not be in force until 1980.

The PMP also provides for reassessment of the OY's and U.S. harvesting and processing capacities in September, 1980, on the basis of updated information on the status of stocks, estimated and actual performance of domestic and foreign fleets, and other relevant factors. Foreign longline vessels holding applicable permits may fish as authorized under these regulations throughout the FCZ beyond 12 nautical miles from the baseline used to measure the U.S. territorial sea. Until the applicable national allocation is reached, foreign vessels holding valid permits will be permitted to fish under those permits and retain oceanic sharks, wahoo, or mahimahi, caught in the applicable fishing area beyond 12 nautical miles from the baseline used to measure the U.S. territorial sea.

The regulations establish retention and non-retention zones for billfish within each fishing area (Table I of § 611.81(b)(2) of the regulations). National allocations for species of billfish must be taken outside non-retention zones. Even if a foreign nation has a billfish allocation, all billfish caught by vessels from that nation within the non-retention zones must be returned to the sea without removing the fish from the water. Billfish caught and returned to the sea in non-retention zones are not counted against national allocations.

When a national allocation, TALFF, or OY for a species of billfish or oceanic sharks is reached in a management area, any additional catch of that species in that area must be returned to the sea without removing the fish from the water. When a national allocation for wahoo or mahimahi is reached, additional catch of these species is treated as a prohibited species and must be returned to the sea immediately, with a minimum of injury, regardless of its condition, in accordance with § 611.13 of this Part.

g. Regulatory Analysis

A draft regulatory analysis of the proposed regulations was prepared. Among the alternatives considered were taking no action, implementing the PMP as originally proposed, prohibiting all retention of billfish in the FCZ, and establishing areas closed to any taking of billfish and associated species. The major reasons for the regulatory approach selected include: (1) Consideration of foreign policy and consistency with U.S. international negotiating positions concerning highly migratory species; (2) recognition of special economic, social, and recreational interests in the management areas of the FCZ; and (3) minimizing reporting and recordkeeping requirements consistent with research and enforcement needs. A final regulatory analysis has been prepared.

In accordance with Executive Order 12044, the Administrator of the National Oceanic and Atmospheric Administration has approved these final regulations and the final regulatory analysis. The final Supplement No. 1 to the EIS will be filed with the Environmental Protection Agency concurrently with the publication of these final regulations.

A copy of the regulatory analysis and the Final Supplement No. 1 to the EIS may be obtained from: Regional Director, National Marine Fisheries Service, National Oceanic and Atmospheric Administration/DOC, 300 South Ferry Street, Terminal Island, CA 90731.

Signed in Washington, D.C., this 28th day of February 1980.

Winfred H. Meibohm,

Executive Director, National Marine Fisheries Service.

(16 U.S.C. 1801 et seq.)

The following amendments should be made in the PMP for Pacific billfish, oceanic sharks, wahoo, and mahimahi published in the Federal Register on July 21, 1978 (43 FR 31374) and in the amendments published on June 15, 1979 (44 FR 34607).

(a) *Original PMP.* (1) p. 31379—II.C.1.a.—end of paragraph 4, delete footnote "5". II.C.1.c.(1)—1st paragraph, change footnote "6" to "5", both in text and at bottom of page. 3rd paragraph, change footnote "7" to "6", both in text and at bottom of page.

(2) p. 31381—change footnote "8" to "7", change footnote "9" to "8", both in text and at bottom of page.

(3) p. 31383—change footnotes "10" and "11" to "9" and "10", both in text and at bottom of page.

(b) *Amended PMP.* (1) p. 34608—3. add "and" between "Wahoo" and "dolphin".

(2) p. 34609—6.(b) add "and" between "Wahoo" and "mahimahi".

(3) p. 34609—9. In II. C.1.c.(2).: (a) at end of 1st paragraph, "(see Table 10)" should read, "(see Table 4)".

(4) p. 34609—10. In II.C.1.c.(3)—delete "Table 3.", and in its place substitute "II.C.2.c.".

(5) p. 34609—14. In II.C.2.c.:(a), delete "is presented in Table 3" and substitute "follows:"—Insert "Table 3" here, but eliminate "Table 3" from the title, leaving "Estimated Average Annual Catch by Portion of the FCZ."

(6) p. 34609—16. In II.C.3., delete "in Table 4." and substitute "as follows:", insert "Table 4" immediately after "as follows:" but eliminate "Table 4" from the title, leaving "OY for billfish, oceanic sharks, and related species, by species, by area."

(7) p. 34609—17. In II.C.4.—delete "Table 1" and substitute "II.C.2.c."

(8) p. 34610—17.(b)—delete "Table 1" and substitute "(see II.C.2.c.)".

(9) p. 34610—17.(b)—delete "In Table 5." and add "as follows:". Insert "Table 5" immediately following "as follows:" but remove "Table 5" from the title leaving "Expected Domestic Harvest, by Species, by Area."

(10) p. 34610—18., last sentence—delete "Table 6." and add "the following table:". Immediately after this, add "Table 6" but delete "Table 6" from the title leaving "OY, Expected Domestic Harvest, and TALFF, by Species, by Area."

(11) p. 34610—22.d.(5)—delete this statement.

(12) p. 34610—23. Delete this statement. Add the following corrections to the tables: Table 3, for American Samoa, in "Domestic" line, add 2.3 under "Blue marlin", add 1.3 under "Sailfish/spearfish", and 2.8 under "Wahoo", and 4.4 under "Mahimahi"; in "Total" line, under "Blue marlin", change 34.9 to 37.2, under "Sailfish/spearfish", change 2.2 to 3.5, under "Wahoo", change 2.0 to 4.8, under "Mahimahi", change 2.0 to 6.4.

(13) p. 34611—Table 4—in "American Samoa" line, under "Blue marlin", change 34.9 to 37.2; under "Sailfish/spearfish", change 2.2 to 3.5; under "Wahoo", change 6.4 to 25.1; under "Mahimahi", change 4.2 to 18.9; in "Total" line, under "Blue marlin" change 788.2 to 790.5; under "Sailfish/spearfish", change 64.0 to 65.3; under "Wahoo", change 297.3 to 318.8; under "Mahimahi", change 111.2 to 130.3.

(14) p. 34611—Table 5—in "West Coast" line, under "Sharks", change 0 to 30.4; in "American Samoa" line, under "Blue marlin", change 0 to 2.3, under "Sailfish/spearfish," change 0 to 1.3, under "Wahoo", change 0 to 2.8, under "Mahimahi", change 2.8 to 4.4; in "Guam and Northern Marianas" line, under "Wahoo", change 7.0 to 27.6; under "Mahimahi", change 4.6 to 20.8; in "Total" column, under "Blue marlin", change 606.4 to 608.7, under "Sailfish/spearfish", change 23.6 to 24.9, under "Sharks", change 0 to 30.4, under "Wahoo", change 324.8 to 348.2, under "Mahimahi", change 120.1 to 140.7.

(15) p. 34611—Table 6—c. Guam and Northern Marianas—in "Wahoo" line, under "OY", change 6.4 to 25.1, under "Expected domestic harvest", change 7.0 to 27.6; in "Mahimahi" line, under "OY" change 4.2 to 18.9, under "Expected domestic harvest", change 4.6 to 20.8; d. American Samoa—in "Blue marlin" line, under "OY", change 34.9 to 37.2, under "Expected domestic harvest", change 0 to 2.3, in "Sailfish/spearfish" line, under "OY", change 2.2 to 3.5, under "Expected domestic harvest", change 0 to 1.3, in "Wahoo" line, under "OY", change 2.0 to 4.8, under "Expected domestic harvest", change 0 to 2.8, in "Mahimahi" line, under "OY", change 2.0 to 6.4, under "Expected domestic harvest", change 0 to 4.4.

The following § 611.81 is added to 50 CFR Part 611, Subpart F:

§ 611.81. Pacific billfish, oceanic sharks, wahoo, and mahimahi fishery.

(a) *Purpose.*—(1) *General.* This section regulates all foreign lingline fishing conducted under a Governing International Fishery Agreement which involves the catching of any species of billfish, oceanic shark, wahoo, or mahimahi (dolphin) in the fishery conservation zone (FCZ) of the United States in the Pacific Ocean, excluding the portion of the FCZ seaward of Alaska.

(2) *Species definitions.* For the purposes of this section, the following terms have the following meanings: (i) "Mahimahi" means "dolphin fish" (*Coryphaena hippurus* and *Coryphaena equisetis*); (ii) "oceanic sharks" means sharks of the families *Carcharhinidae, Alopiidae, Sphyrnidae,* and *Lamnidae;* (iii) "billfish" means broadbill swordfish (*Xiphias gladius*), blue marlin (*Makaira nigricans*), black marlin (*Makaira indica*), striped marlin (*Tetrapturus audax*), sailfish (*Istiophorus platypterus*), and shortbill spearfish (*Tetrapturus angustirostris*); and (iv) "wahoo" means fish of the species *Acanthocybium solanderi.*

(b) *Authorized fishery.*—(1) *Regulatory areas.* For the purposes of this section, the FCZ of the Pacific Ocean (excluding the FCZ seaward of Alaska) is divided into five regulatory areas: West Coast, Guam and the Northern Mariana Islands, Hawaii and Midway Islands, American Samoa, and U.S. Possessions (Table 1).

(2) *Zones.* The regulatory areas are comprised of the following "billfish retention" and "billfish non-retention" zones (each zone is measured from the baseline used to measure the U.S. territorial sea):

Table 1

Regulatory area	Billfish retention zones	Billfish nonretention zones
West Coast	Beyond 100 nautical miles	Betwen 12 and 100 nautical miles.
Guam and Northern Mariana Islands.	(1) Beyond 50 nautical miles from Guam, Rota, Tinian, Aguijan, and Saipan; and (2) beyond 12 nautical miles of the remaining islands of the Northern Mariana Islands.	Between 12 and 50 nautical miles from Guam, Rota, Tinian, Aguijan, and Saipan.
Hawaii and Midway Islands	(1) Beyond 100 nautical miles from the islands of Hawaii, Kahoolawe, Kauai, Lanai, Maui, Molokai, Niihau, and Oahu; and (2) beyond 50 nautical miles from the remaining islands of the State of Hawaii and Midway Islands.	(1) Between 12 and 100 nautical miles from the islands of Hawaii, Kahoolawe, Kauai, Lanai, Maui, Molokai, Niihau, and Oahu; and (2) between 12 and 50 nautical miles from the remaining islands of the State of Hawaii and Midway Islands.
American Samoa	Beyond 12 nautical miles from American Samoa.	No nonretention zone.
U.S. Possessions	Beyond 12 nautical miles from any other possession of the United States in the Central and Western Pacific Ocean.	No nonretention zone.

(3) *General.* Foreign vessels subject to this section are authorized to fish in the U.S. FCZ of the Pacific Ocean (excluding the FCZ seaward of Alaska) beyond 12 miles from the baseline used to measure the U.S. territorial sea, subject to the requirements of this section.

(i) *Non-retention fishery.* Except as provided in paragraph (b)(3)(ii) of this section, all billfish, oceanic sharks, wahoo, mahimahi, and other fish caught by foreign vessels in the course of fishing under this section shall be returned to the sea in accordance with the requirements of paragraph (c) of this section.

(ii) *Retention fishery.* Foreign vessels fishing subject to this section may retain billfish, oceanic sharks, wahoo, and mahimahi to the extent that retention is authorized by paragraphs (b)(4) and (5) of this section.

(4) *Total allowable level of foreign fishing (TALFF); national allocations and reserves.*—(i) *TALFF and national allocations.* (A) The total amount of each species of billfish, oceanic sharks, wahoo, and mahimahi which may be caught and retained in each regulatory area by foreign vessels subject to this section is limited to the TALFF set out for each applicable regulatory area in Appendix I of § 611.20, and to the amount of the applicable national allocation.

(B) No foreign vessel subject to this section may catch and retain billfish within the billfish non-retention zones set out in Table I of paragraph (b)(2) of this section.

(ii) *Reserves.*—(A) *Amounts.* The amounts of fish held in reserve are stated in Appendix I of § 611.20.

(B) *Determination.* (*1*) As soon as practicable after September 1 of each year, the Regional Director, Southwest Region, shall determine, for each species for which a reserve has been established, the amount of fish which has been harvested to date by U.S. vessels in each applicable regulatory area.

(*2*) If the Regional Director determines that the amount of fish of a species harvested by vessels of the United States in an area is less than 80 percent of the expected domestic harvest for that species in that area, the Regional Director shall apportion to TALFF the entire amount of the reserve for the applicable species in the applicable regulatory area. No reserve amounts shall be apportioned to TALFF if domestic vessels have harvested 80 percent or more of the expected domestic harvest for that species in the applicable area by the date of this determination.

(C) *Notice.* The Assistant Administrator for Fisheries, NOAA, shall publish in the Federal Register a notice of each determination made under paragraph (b)(4)(ii)(B) of this section.

(5) *Cancellation of authority to retain.* (i) The authority of a foreign vessel to retain an applicable species is cancelled:

(A) When the national allocation for the applicable species is reached; or

(B) At the date and time specified in the notification issued by the Assistant Administrator under paragraph (b)(5)(ii) of this section.

(ii) The Assistant Administrator shall determine, on the basis of the information specified in § 611.15(b), when the TALFF or optimum yield (OY) for a billfish species, oceanic sharks, wahoo, or mahimahi in a regulatory area will be reached. At least forty-eight hours before the applicable TALFF or OY will be reached, the Assistant Administrator shall notify both the affected foreign nation(s) and the designated representative for any affected fishing vessel that authority to retain the applicable species is cancelled.

(iii) Any cancellation under this section shall remain in effect until a new or increased allocation becomes available.

(iv) The closure provisions of § 611.15 do not apply to foreign vessels fishing subject to this section.

(c) *Prohibited species.*—(1) *General.* The following are prohibited species under this section:

(i) All species of fish over which the United States exercises exclusive fishery management authority and for which there is no national allocation;

(ii) All billfish, oceanic sharks, wahoo and mahimahi caught in excess of an applicable OY, TALFF, or national allocation; and

(iii) All billfish caught in a billfish non-retention zone. (See Table I of paragraph (b)(2) of this section.)

(2) *Treatment.* All prohibited species shall be treated in accordance with § 611.13.

(3) *Additional requirements for billfish and oceanic sharks.* Unless otherwise specifically instructed by a U.S. observer or authorized officer, all prohibited billfish and oceanic sharks must be released by cutting the line (or by other appropriate means) without removing the fish from the water.

(4) *Rebuttal of presumption.* Foreign vessels fishing subject to this section may rebut the presumption of § 611.13(c) by: (i) Storing all prohibited species caught outside the FCZ in a separate part of the vessel hold which can be sealed, and arranging inspection and sealing of the vessel hold by U.S. authorities before commencing fishing in the FCZ or in billfish non-retention zones; or (ii) other reasonable means which may be authorized by the Administrator of the Western Pacific Program Office (WPPO) if, in consultation with the U.S. Coast Guard, the Administrator of WPPO, determines that special circumstances warrant alternative arrangements.

(5) *Procedure for hold sealing.* (i) Inspection and sealing of a foreign vessel's hold may be arranged by contacting the Administrator, WPPO (Southwest Region, National Marine Fisheries Service, Post Office Box 3830, Honolulu, Hawaii 96812, telephone: 808–946–2181) at least 48 hours in advance of the date for which inspection is requested.

(ii) Ports at which such inspections may be made are Honolulu and Kahului, Hawaii; Pago Pago, American Samoa; Agana, Guam; Saipan, Northern Mariana Islands; and San Diego, California.

(iii) Additional ports for hold inspections may be arranged with the Administrator, WPPO.

(6) *Other requirements.* The designation of ports for hold inspection and sealing does not modify any port entry arrangements or requirements (if any) of Governing International Fishery Agreements or the notification requirements of any other laws or regulations of the United States.

(d) *Vessel reporting.* (1) In lieu of the vessel reporting requirements of § 611.4, the owner or operator of each foreign fishing vessel engaging in the Pacific billfish, oceanic sharks, wahoo, and mahimahi fishery shall notify the Coast Guard in the manner set forth in paragraph (d)(3) of this section, of:

(i) The date of the Sunday beginning the week during which each vessel intends to *begin* fishing in the FCZ (action code BEGIN), the fishing area and the approximate longitude and latitude where it intends to begin fishing; (see paragraph (d)(5) of this section for use of action codes); and

(ii) The date of the Sunday beginning the week during which each vessel intends to *cease* fishing in the FCZ (action code CEASE) and the fishing area where it intends to cease fishing, with the approximate longitude and latitude.

(2) For purposes of this paragraph (d) of this section, a week shall begin at 0001 G.m.t. each Sunday. The fishing areas are listed in Appendix II to § 611.9.

(3) The vessel reports required by this paragraph (d):

(i) Shall be in English;

(ii) Shall be delivered via commercial facilities to the appropriate Coast Guard commander who will relay them to the appropriate National Marine Fisheries Service Region (see Table I of § 611.4 for appropriate Coast Guard and National Marine Fisheries Service addresses);

(iii) Shall be delivered not later than seven days prior to the Sunday beginning the earliest week included in the report;

(iv) Need not be submitted on temporary departures from the FCZ, such as for port calls (inside the seaward boundary of one of the coastal states) or when operating at and occasionally outside the seaward limits of the FCZ; and

(v) Shall include departure from one fishing area and entry into another fishing area.

(4) Minor modifications in times reported in paragraph (d)(1) of this section, as necessitated by changing fishing conditions, weather, or vessel operating conditions, need not be reported. Major changes should be reported at the earliest practicable date. Examples of major changes include: cancellation of a vessel's previously reported intentions to fish in a fishing area, and changes of more than two weeks in a previously reported time of arrival in, or departure from, a fishing area. The addition of an area to a vessel's fishing intentions requires the basic report of paragraph (d)(1) of this section.

(5) The vessel reports required by this paragraph (d) shall contain the following information: The message identifier "PACREP" to indicate it is a required vessel report in the Pacific billfish, oceanic sharks, wahoo, and mahimahi fishery; vessel name; international radio call sign; the date (month and day) of the Sunday on which the weekly period begins; the fishing area; the approximate longitude and latitude that it will enter and leave a fishing area; and the appropriate action code (BEGIN or CEASE).

(6) Vessel reports are required for each vessel. The vessel reports required by this paragraph (d) should be consolidated, if possible, and submitted for groups of vessels (on a vessel-by-vessel basis) by a designated representative for a foreign nation's fishing vessels. Illustrations of reports follow:

(i) Able Steamship Company, designated representative for Bolivian longliners, wishes to report the vessel *CABLE* (EXRC) which will begin fishing in the Hawaii and Midway Islands FCZ (area code 81) between February 10 and 16, 1980; cease fishing in that FCZ approximately February 26; begin fishing in the Johnston Atoll FCZ (area code 84) about February 28; cease fishing in the Johnston Atoll FCZ between March 2 and 8; begin fishing in the American Samoa FCZ (area code 83) about April 7; and cease fishing in the American Samoa FCZ about May 21. Able Steamship Company also wishes to report the vessel *DABBLE* (EQUP)

which will begin fishing in the American Samoa FCZ on February 19 and cease fishing on March 18. He will then go to Howland and Baker Islands FCZ (area code 85) about March 23 and cease fishing on April 20. The required message must be delivered not later than February 3 to Commander, 14th Coast Guard District. The message would be transmitted as follows:

From: Able Steamship Company
To: Commander, 14th Coast Guard District, Honolulu, Hawaii (Telex: 392401); Southwest Region, NMFS, Terminal Island, CA
PACREP
CABLE/EXRC/0210/2710N/17920W/81/
BEGIN//0224/2210N/16005W/81/
CEASE//0224/1710N/17010W/84/
BEGIN//0302/1705N/17205W/84/
CEASE//0406/1510S/16510W/83/
BEGIN//0518/1435S/16640W/83/
CEASE//DABBLE/EQUP/0217/1405S/
16600W/83/BEGIN//0316/1650S/
16610W/83/CEASE//0323/0510S/
17800W/85/BEGIN//0420/0230N/
17930E/85/CEASE//

(ii) In the above illustration, Able Steamship Company subsequently learns that the vessel *Cable* ceased fishing in the Johnston Atoll FCZ on March 19 (a minor modification which need not be reported) and intends to cease fishing in the American Samoa FCZ about June 27 instead of May 21 (a modification which must be reported). Further, the vessel *Dabble* no longer intends to fish in the American Samoa FCZ (a modification which must be reported). The text of the message would appear as follows:

PACREP
CHANGE CABLE/EXRC/0518/1435S/
16640W/83/CEASE//to 0622/1435S/
16640W/83/CEASE//
CANCEL DABBLE/EQUP/0217/1405S/
16600W/83/BEGIN//0316/1650S/
16610W/83/CEASE//

(e) *Collection and Reporting of Data.* In lieu of the requirements of § 611.9 (d), (e), and (g), the following data collection and reporting requirements shall apply.

(1) *Daily cumulative catch log.* All foreign fishing vessels shall maintain a daily cumulative catch log in English. This log shall contain on a daily and cumulative basis data on all billfish, oceanic shark, wahoo, mahimahi, and other fish caught in the FCZ during the permit period. The log shall be maintained aboard the vessel during the duration of the permit period. Information for each fishing area shall be maintained on a separate page of the log. The log shall contain the following information:

(i) Name and call sign of the vessel;

(ii) Permit number;

(iii) Fishing area and area code number where fishing is conducted (see Appendix II to § 611.9);

(iv) Date;

(v) Noon-day position of vessel, within one-tenth of 1° longitude and latitude;

(vi) Number and round weight (in kilograms) of each species (by species codes) of billfish, oceanic sharks, wahoo, and mahimahi caught and retained each day and cumulatively;

(vii) Number of each species (by species codes) of billfish, oceanic shark, wahoo, mahimahi, and other fish caught and released each day and cumulatively;

(viii) Number of fish of each species released alive, each day and cumulative; and

(ix) Number of hooks set by type of bait.

(2) *Quarterly catch report.* Each foreign nation whose vessels fish under this section shall submit, through the designated representative, a quarterly report containing, on a vessel-by-vessel basis, the following information:

(i) Name of the vessel;

(ii) Permit number;

(iii) Month and day of the last day of the period covered by the report;

(iv) For each fishing area where fishing occurred during the reporting period:

(A) Number and round weight of each allocated species caught and retained to the nearest tenth of a metric ton (0.1 m.t.);

(B) Number of each species of billfish, oceanic shark, wahoo, mahimahi, and other fish caught and released during the reporting period;

(C) Number of fish of each species released alive;

(D) Total number of hooks set, by type and bait;

(E) Number of days fished in the FCZ during the reporting period; and

(F) Average number of hooks set per day fished, by type of bait.

(3) *Quarterly report of marine mammal incidental catch.* Each foreign nation whose vessels fish under this section shall submit, through the designated representative, the report of marine mammal incidental catch required by § 611.9(g) on a quarterly basis in lieu of weekly reports.

(4) *Submission of reports.* The quarterly reports required by this paragraph (e) shall be submitted within 60 days of the end of each calendar quarter to:

Regional Director, Southwest Region, National Marine Fisheries Service, 300 South Ferry Street, Terminal Island, California 90731, Telephone: 213–548–2575.

50 CFR Part 611 is amended as follows:

§ 611.9 [Appendix IB Amended]

(A) Section 611.9, Appendix IB—Species Codes, Pacific Ocean Fishes, under Finfishes:

(1) Add:

Code, Common English Name, and Scientific Name

469—Other sharks (NS)—Squaliformes

(2) Change scientific name for black marlin to *Makaira indica.*

§ 611.9 [Appendix IIB Amended]

(B) Section 611.9, Appendix IIB, Area Codes—Pacific, delete entries with code numbers 81, 82, and 83, and the accompanying footnote, and replace with the following:

	Name	Figure No.
Code No.:		
81	Hawaii and Midway Islands	
82	Guam and Northern Mariana Islands.	
83	American Samoa	
84	Johnston Atoll	
85	Howland and Baker Islands	
86	Kingman Reef and Palmyra Atoll.	
87	Jarvis Island	
88	Wake Island	

§ 611.80 [Amended]

(C) Section 611.80(a), add between the words "fishing" and "conducted", the phrase "for pelagic armorheads and alfonsins."

(D) Section 611.80(b)(3), add to the end of the sentence

* * * * *

(b) * * *

(3) * * * except billfish, oceanic sharks, wahoo, and mahimahi, and other fish caught pursuant to § 611.81.

(E) Section 611.20, Appendix I, is amended by inserting the following into the table:

Appendix 1.—*Section 611.20 [Amended]*

Species	Species code	Areas	OY—optimum yield (metric tons)	Domestic allowable harvest (DAH) (metric tons)	JVP—estimated joint venture harvest [1] (metric tons)	Reserve	TALFF
3. Western Pacific Ocean fisheries:							
B. Pacific billfish and sharks fishery:							
Swordfish	264	West coast	318.4	350.2		0	0
		Hawaii and Midway Islands	93.6	5.9		8.8	78.9
		Guam and Northern Mariana Islands.	4.1	0.2		0.4	3.5
		American Samoa	2.4	0		0	2.4
		U.S. possessions	28.1	0		0	28.1
Blue marlin	260	West coast					
		Hawaii and Midway Islands	612.0	603.4		8.6	0
		Guam and Northern Mariana Islands.	26.9	3.0		23.9	0
		American Samoa	37.2	2.3		0	34.9
		U.S. possessions	76.3	0		0	76.3
Black marlin	253	West coast					
		Hawaii and Midway Islands	97.7	104.7		0	0
		Guam and Northern Mariana Islands.	0.6	0		0.1	0.5
		American Samoa	5.3	0		0	5.3
		U.S. possessions	6.2	0		0	6.2
Striped marlin	261	West coast	43.2	47.5		0	0
		Hawaii and Midway Islands	223.2	67.9		15.5	139.8
		Guam and Northern Mariana Islands.	5.0	0.3		0.5	4.2
		American Samoa	7.8	0		0	7.8
		U.S. possessions	46.6	0		0	46.6
Sailfish/spearfish	252, 262	West coast					
		Hawaii and Midway Islands	42.7	23.4		1.9	17.4
		Guam and Northern Mariana Islands.	4.8	0.2		0.5	4.1
		American Samoa	3.5	1.3		0	2.2
		U.S. possessions	14.3	0		0	14.3
Sharks	263, 265, 266, 267, 469	West coast	27.6	30.4		0	0
		Hawaii and Midway Islands	1,111.6	0		111.1	1,000.5
		Guam and Northern Mariana Islands.	31.9	0		0	31.9
		American Samoa	101.6	0		0	101.6
		U.S. possessions	651.4	0		0	651.4
Wahoo	255	West coast					
		Hawaii and Midway Islands	288.9	317.8		0	0
		Guam and Northern Mariana Islands.	25.1	27.6		0	0
		American Samoa	4.8	2.8		0	2.0
		U.S. possessions	0	0		0	0
Mahimahi	238, 237	West coast					
		Hawaii and Midway Islands	105.0	115.5		0	0
		Guam and Northern Mariana Islands.	18.9	20.8		0	0
		American Samoa	6.4	4.4		0	2.0
		U.S. possessions	0	0		0	0

[1] JVP is a subset of DAH.

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U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
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RESULTS OF BOTTOM FISH RESEARCH IN THE NORTHWESTERN HAWAIIAN ISLANDS

By

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INTRODUCTION

From October 1976 to September 1981, the Honolulu Laboratory, Southwest Fisheries Center, National Marine Fisheries Service (NMFS), under a Tripartite Cooperative Agreement with the U.S. Fish and Wildlife Service and the State of Hawaii's Division of Aquatic Resources, Department of Land and Natural Resources (DLNR), conducted surveys of the demersal and coastal pelagic fishes and macroinvertebrates of the island shelves, banks, reefs, seamounts, and overlying waters within the U.S. Fishery Conservation Zone around the Northwestern Hawaiian Islands (NWHI). The University of Hawaii Sea Grant Program also became a partner to this investigation about a year later. The resource assessment surveys were conducted in response to recommendations by the Governor's Task Force on Oceanography (State of Hawaii 1969) and on Hawaii and the Sea (State of Hawaii 1974) to investigate the magnitude of the marine resources in waters of the NWHI as well as to learn about the interaction of these marine resources with terrestrial animals such as the endangered Hawaiian monk seal, Monachus schauinslandi, green turtle, Chelonia mydas, and sea and land birds that reside on the islands.

Results of the first phase of the bottom fish survey, conducted in October 1976-June 1979, were summarized by Uchida et al. (1979) and by Moffitt.[1] These papers describe the sampling procedure, the gears used, and present results of studies on bottom fish distribution and relative abundance, spawning and fecundity, food and feeding behavior, ciguatera, and age and growth.

This paper summarizes the results of all NMFS bottom fish studies conducted to date in the NWHI. It includes brief reviews of studies completed or ongoing on distribution, relative abundance, and cluster analysis; age and growth; food and feeding habits; ciguatera; fecundity and spawning; and length-weight relationships.

THE BOTTOM FISH RESOURCE

The volcanic processes by which the Hawaiian Islands were built up from the ocean floor produced relatively steep-sided bases for all the islands. Newman (1976) pointed out that these island bases are less than 250 km in width at the bottom and that the slope averages about 400 m/km. It is this steep underwater gradient that limits the shelf zone to a narrow band that surrounds each island, a factor which is vitally important to fishing in Hawaiian waters. Unlike the continental shelf that characterizes most of the world's great fishing areas, the island shelf is narrow, poorly developed, and does not offer the marine environmental conditions that are so vital to high fishery yields.

The Hawaiian commercial fishery exploits about 60-70 species of the 680+ species of fish reported to occur in Hawaiian waters. The bulk of the landings is from within 20 nmi of the main islands; however, in recent years long-ranging vessels of the Hawaiian fleet have begun to make larger contributions to the State landings with fish and shellfish harvested from waters of the NWHI.

The demersal fish resource of the NWHI can be conveniently divided into three groups or species complex, depending on their vertical distribution over the island shelf and slope or over the summit of

seamounts. The first is the reef fish complex occupying the subsurge zone over the inner and outer shelves, the second is the snapper-grouper complex inhabiting the shelf edge down to the bottom of the upper slope zone, and the third is the armorhead-alfonsin complex associated with the summits of some of the seamounts in the northern edge of the Hawaiian Archipelago. This report will be concerned only with the snapper-grouper complex; the reef fish complex was essentially researched by the DLNR and the results of their study are not included here. The seamount-groundfish resource, which includes the pelagic armorhead, Pentaceros richardsoni, and alfonsin, Beryx splendens, has been reported on by Uchida and Tagami.[2]

FISHES OF THE SNAPPER-GROUPER COMPLEX

The species included in this category are opakapaka, Pristipomoides filamentosus, kalekale, P. sieboldii, gindai, P. zonatus. onaga, Etelis coruscans, ehu, E. carbunculus, hapuupuu, Epinephelus quernus, butaguchi, Pseudocaranx dentex, kahala, Seriola dumerili, and nohu, Pontinus macrocephalus.

Relative Abundance

During the course of the NWHI investigation, we fished 25 banks with handline gear to determine the distribution and relative abundance of bottom fish species. Among the more productive banks were Nero Seamount where 18.8 line-h of fishing produced 5.319 fish/line-h with ehu predominating in the catch. Other banks with excellent fishing were Bank No. 9, a submerged pinnacle located at lat. 27°00'N, long. 175°35'W, where the catch rate reached 3.608 fish/line-h and ehu, hapuupuu, and kahala dominated the catch, and at Pearl and Hermes Reef where the catch rate was

3.252 fish/line-h in 234.93 line-h of fishing. The catch at Pearl and Hermes was composed predominantly of ehu, hapuupuu, butaguchi, kahala, kalekale, onaga, and nohu. We also experienced relatively good fishing for bottom fish at Midway, Maro Reef, French Frigate Shoals, and Bank No. 8, located at lat. 26°17'N, long. 174°34'W. Analysis of the bottom fish data is continuing.

Age Determinations

Age determinations of bottom fish were made on the assumption that rings in otoliths indicated daily marks and in some species, annual marks. Previous studies have supported the hypothesis that the smallest discernible growth increments in the sagittae of fish are deposited daily (Pannella 1971, 1974). Recent studies have provided direct evidence that these growth increments are daily phenomena in sagittae of both temperate (Brothers et al. 1976; Taubert and Coble 1977; Barkman 1978) and tropical species (Ralston 1976; Struhsaker and Uchiyama 1976; Wild and Foreman 1980). We have completed a number of studies on age and growth for such species as opakapaka, gindai, ehu, and kahala. Studies on kalekale and hapuupuu are currently in progress and should be completed shortly.

Figure 1 shows the growth curves for opakapaka, ehu, and kahala for which studies have been completed. Based on 93 fish, the von Bertalanffy growth parameters for opakapaka were as follows: L_∞ = 97.1 cm; K = 0.31; and t_o = 0.02 yr. Growth parameters of the kahala, based on 14 fish including juveniles less than 4 cm in fork length (FL) as well as adults, were L_∞ = 149.4 cm; K = 0.31; and t_o = 0.04 yr. The growth parameters of ehu, based on 14 fish from 23 to 49 cm FL were L_∞ = 63.9 cm; K = 0.36; and

t_o = -0.60 yr. It should be noted that the L_∞ calculated for ehu was almost identical to the size of the largest ehu taken, which measured 63.0 cm FL.

Cluster Analysis

We have also used multivariate techniques to document biological variation in waters of the NWHI. A statistical technique called cluster analysis used on a sample of 4,319 bottom fish caught in the NWHI over the past 5 yr suggests that the banks can be aggregated.[3] Grouping the data into six clusters gave the greatest reduction in variance among the species composition vectors. Nihoa, Lisianski, and Pearl and Hermes formed one cluster with catches consisting primarily of ehu and hapuupuu. Northampton Seamount, by itself, formed a second cluster with catches predominated by ehu and gindai. A third cluster was formed by Gardner Pinnacles, Laysan, and Raita Bank where the catch was predominately composed of ehu, opakapaka, butaguchi, hapuupuu, and kahala. Midway and Kure formed a fourth cluster with catches predominantly composed of ehu, hapuupuu, and butaguchi. The fifth cluster included Necker, French Frigate Shoals, and Brooks Banks where the catches primarily included opakapaka and hapuupuu. The final cluster detected was Maro Reef which had predominantly opakapaka, hapuupuu, and butaguchi.

Food and Feeding Habits

Determination of the food and feeding habits of several members of the snapper-grouper complex is extremely difficult because when the fish are hooked at depths of about 130-240 m and brought to the surface, expansion

of the gas bladder invariably causes the stomach to evert, leaving only traces of food items either caught in the throat or gill rakers. For some species such as the carangids, however, entire stomachs can be collected for study.

Among fishes of the snapper-grouper complex, we have completed diet studies on kahala, butaguchi, and hapuupuu. Brief summaries of the results are given below.

Butaguchi: The butaguchi, like many other members of the Family Carangidae, is an opportunistic bottom feeder (Seki [4]). In 64 stomachs examined, fishes of the Families Congridae, Priacanthidae, and Serranidae were the most important and cephalopods, crabs, and shrimps were the most important invertebrates. Fish occurred in 69% of the stomachs and represented 20 families. The invertebrates included four phyla with the majority beonging to Arthropoda, Class Crustacea. Crustaceans were found in 53% of the samples with crabs of the Suborder Reptantia, the most frequently encountered. Caridean shrimps, stomatopods, and amphipods were also important constituents of the diet.

Hapuupuu: Because of the difficulty in collecting intact stomachs from this species, sampling concentrated also on spew samples, that is, food items that were caught in the throat or gill rakers of the fish (Seki[5]). Fish representing 22 families occurred in 60% of the samples; members of the Families Lutjanidae, Emmelichthyidae, and Congridae were the most important. Crustaceans were the most important among the invertebrates and were present in 51% of the samples. The crustaceans included shrimps of

which members of the Family Pandalidae were the most frequently encountered. Crabs, stomatopods, amphipods, and isopods made up the bulk of the remaining invertebrates. Molluscs represented only a small part of the diet, being present in only 6% of the samples.

Kahala: Our study on kahala had two objectives: One was to learn about the feeding habits of the species and the second was to compare feeding habits of ciguatoxic and nonciguatoxic fishes. The results showed that among large kahala, that is, those larger than 9 kg, mackerel scad, Decapterus sp., were the most important food item irrespective of the area of capture or ciguatoxicity (Humphreys and Kramer6). For kahala smaller than 9 kg, mackerel scad were again the predominant food item but with two exceptions: those taken in the NWHI and those ciguatoxic fish taken in the lower main Hawaiian Islands had fed relatively more on bottom-associated fauna including shrimps, other crustaceans, lizardfish, and scorpaenids. From these results, the investigators hypothesized that small kahala in the lower main Hawaiian Islands are more susceptible to ciguatoxin contamination and that the occurrence of large, ciguatoxic kahala was primarily the result of the toxin's long retention time. They also suggested that conditions for ciguatoxin production are less optimal in the NWHI than in the lower main Hawaiian Islands and that a more readily available bottom-associated prey fauna exists for small kahala in the NWHI.

Length-Weight and Standard Length-Fork Length Relationships

Uchiyama et al.[7] determined the length-weight and standard length-fork length relationships for the kahala, butaguchi, opakapaka,

kalekale, gindai, ehu, onaga, and hapuupuu from the NWHI. The results of this study showed that except for hapuupuu, there was no significant difference between mean weight for males and females. The highly significant difference between the sexes observed for hapuupuu was attributed to the very small sample size for the males. Comparison of group means also showed significant differences among cruises for kahala, butaguchi, opakapaka, ehu, and hapuupuu and among banks for all the species studied except butaguchi. The investigators explained these differences as a result of uneven distribution of commercial fishing pressure on the banks, that is, those banks closer to the inhabited main islands were fished down first whereas the more distant banks were pristine with large fish predominating in the catch.

The regression equations describing the length-weight and standard length-fork length relationships of the eight species are given in Tables 1 and 2.

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TEXT FOOTNOTES

[1]R. B. Moffitt. 1980. Groundfish resources of the central and western Pacific. Unpubl. manuscr. Southwest Fish. Cent., Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 96812, 17 p.

[2]R. N. Uchida and D. T. Tagami. Manuscr. in prep. Fishery for groundfish over seamounts in the North Pacific Ocean. Southwest Fish. Cent., Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 96812.

[3]J. J. Polovina, Southwest Fish. Cent., Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 96812, pers. commun., April 13, 1982.

[4]M. P. Seki. Manuscr. in prep. The food and feeding habits of the thick-lipped trevally, Pseudocaranx dentex (Bloch and Schneider) in the Northwestern Hawaiian Islands. Southwest Fish. Cent., Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 96812.

[5]M. P. Seki. Manuscr. in prep. The food and feeding habits of the sea bass, Epinephelus quernus Seale in the Northwestern Hawaiian Islands. Southwest Fish. Cent., Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 96812.

[6]R. L. Humphreys, Jr. and S. H. Kramer. Manuscr. in prep. Ciguatera and the feeding habits of the greater amberjack, Seriola dumerili, in the Hawaiian Archipelago. Southwest Fish. Cent., Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 96812.

[7]J. H. Uchiyama, S. H. Kuba, and D. T. Tagami. Manuscr. in prep. Length-weight and standard length-fork length relationships of deep-sea handline-caught fishes of the Northwestern Hawaiian Islands. Southwest Fish. Cent., Natl. Mar. Fish. Serv., NOAA, Honolulu, HI 96812.

Table 1.--Length-weight relationships of fishes commonly caught in the deep-sea handline fishery in the Northwestern Hawaiian Islands (see text footnote 7).

Species	Equation[1]	Y-axis intercept	Regression coefficient	N	Correlation coefficient	Fork length max. (mm)	Fork length min. (mm)
Seriola dumerili	1	2.6066	0.3348	74	0.982	1,115	524
	2	-7.4727	2.8791				
	3	2.2601	0.3410				
	4	-7.6275	2.9327				
Pseudocaranx dentex	1	2.5879	0.3229	123	0.979	830	464
	2	-7.6509	2.9676				
	3	2.5831	0.3299				
	4	-7.8310	3.0316				
Pristipomoides filamentosus	1	2.5857	0.3427	211	0.992	779	268
	2	-7.4102	2.8691				
	3	2.5816	0.3506				
	4	-7.4772	2.8934				
Pristipomoides sieboldii	1	2.5760	0.2806	71	0.922	435	245
	2	-7.8283	3.0306				
	3	2.5794	0.3043				
	4	-8.4769	3.2864				
Pristipomoides zonatus	1	2.5571	0.2998	57	0.977	469	282
	2	-8.1330	3.1833				
	3	2.5560	0.3069				
	4	-8.3288	3.2585				
Etelis carbunculus	1	2.5856	0.3240	474	0.987	629	269
	2	-7.7587	3.0036				
	3	2.5843	0.3284				
	4	-7.8682	3.0447				
Etelis coruscans	1	2.5993	0.3376	44	0.979	880	480
	2	-7.3542	2.8399				
	3	2.5945	0.3448				
	4	-7.5248	2.9003				
Epinephelus quernus	1	2.5971	0.3105	284	0.989	[2]1,100	235
	2	-8.1604	3.1486				
	3	2.5945	0.3140				
	4	-8.2618	3.1844				

[1]Predictive equation 1: $\log_{10}X = \log_{10}a + b \log_{10}Y$
Predictive equation 2: $\log_{10}Y = \log_{10}c + d \log_{10}X$
Functional equation 3: $\log_{10}X = \log_{10}u + v \log_{10}Y$
Functional equation 4: $\log_{10}Y = \log_{10}w + x \log_{10}X$

where X = fork length (mm)
Y = weight (kg)
Y-intercept: a, c, u, w
regression coefficient: b, d, v, x

[2]Total length.

Table 2.--Standard length-fork length relationships of fishes commonly caught in the deep-sea handline fishery in the Northwestern Hawaiian Islands (see text footnote 7).

Species	Equation[1]	Y-axis intercept	Regression coefficient	n	Correlation	Range of fork length maximum (mm)	Range of fork length minimum (mm)	Range of standard length maximum (mm)	Range of standard length minimum (mm)
Seriola dumerili	1	3.5344	0.9391	74	0.996	1,494	524	1,367	504
	2	2.1377	1.0572						
	3	0.7493	0.9425						
	4	-0.7889	1.0610						
Pseudocaranx dentex	1	-0.1106	0.9448	129	0.997	830	464	772	431
	2	4.6975	1.0510						
	3	-2.2639	0.9481						
	4	2.4134	1.0547						
Pristipomoides filamentosus	1	2.5515	0.9012	203	0.997	779	268	723	242
	2	0.5081	1.1034						
	3	1.0884	0.9037						
	4	-1.1713	1.1065						
Pristipomoides sieboldii	1	4.2166	0.8983	70	0.987	435	245	403	225
	2	4.0474	1.0853						
	3	0.0356	0.9098						
	4	-0.0218	1.0992						
Pristipomoides zonatus	1	-13.889	0.9506	42	0.985	489	282	452	256
	2	26.828	1.0207						
	3	-20.0176	0.9650						
	4	20.7707	1.0362						
Etelis carbunculus	1	-2.8201	0.9185	434	0.993	629	269	581	241
	2	9.8694	1.0728						
	3	-6.0045	0.9253						
	4	6.5023	1.0807						
Etelis coruscans	1	-0.5400	0.9169	40	0.998	480	876	440	810
	2	3.4976	1.0859						
	3	-1.8766	0.9189						
	4	2.0160	1.0883						
Epinephelus quernus	1	-13.152	0.8630	289	0.997	[2]1,100	235	956	181
	2	18.896	1.1525						
	3	-14.758	0.8653						
	4	17.096	1.1556						

[1]Prediction equation 1: $X = a + b\,Y$
Prediction equation 2: $Y = c + d\,X$
Functional equation 3: $X = u + v\,Y$
Functional equation 4: $Y = w + y\,X$

where X = standard length
Y = fork length
Y intercept: a, c, u, w
regression coefficient: b, d, v, y

[2]Total length

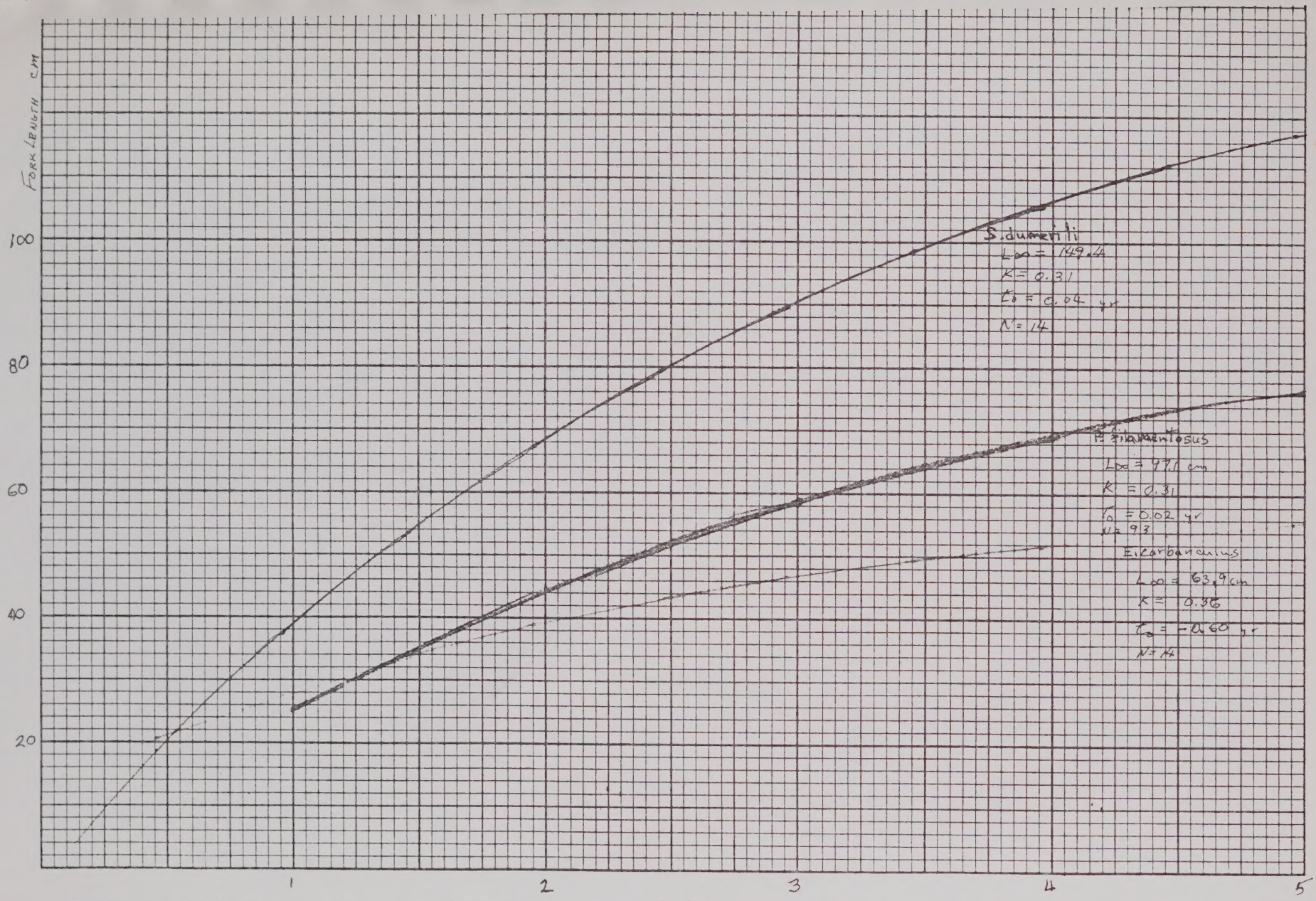

Figure 1.--Estimated growth curves of Seriola dumerili, Pristipomoides filamentosus, and Etelis carbunculus from the Northwestern Hawaiian Islands as determined from otolith examinations.